GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: 10-11-79

Project Title: "Water Treatment Equipment Testing Related to Borangay Water"

Project No: B-538 (sub-project is E-26-649/Craft/NE) C O

Project Director: P.W. Potts

Sponsor: National Water Well Association under contract with U.S. AID

Agreement Period: From 8/8/79 Until ~~12/31/79~~ 4/12/83

Type Agreement: Letter subcontract from National Water Well Association

Amount: $72,654 ($53,502 - B-538 and $19,152 - E-26-649

Reports Required: Final Report

Sponsor Contact Person (s):

Technical Matters

Contractual Matters
(thru OCA)

Dr. Jay H. Lehr
Executive Director
National Water Well Association
500 West Wilson Bridge Rd.
Worthington, Ohio 43085

Defense Priority Rating:

Assigned to: EEL/IPO (School/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
Dean/Director—EES
Accounting Office
Procurement Office
Security Coordinator (OCA)
Reports Coordinator (OCA)

Library, Technical Reports Section
EES Information Office
EES Reports & Procedures
Project File (OCA)
Project Code (GTRI)
Other E-26-649 Distribution

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: March 5, 1981

Project Title: Water Treatment Equipment Testing Related to Barangay Water

Project No: B-538

Project Director: P. W. Potts

Sponsor: National Water Well Association under contract with U. S.

Effective Termination Date: 4/14/80

Clearance of Accounting Charges: 4/14/80

Grant/Contract Closeout Actions Remaining:

X Final Invoice and Closing Documents
_ Final Fiscal Report
_ Final Report of Inventions
_ Govt. Property Inventory & Related Certificate
_ Classified Material Certificate
_ Other ____________

Assigned to: TAL/IPO (School/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
Dean/Director—EES
Accounting Office
Procurement Office
Security Coordinator (OCA)
~~Reports Coordinator~~ (OCA)

Library, Technical Reports Section
EES Information Office
Project File (OCA)
Project Code (GTRI)
Other Mr. C. E. Smith

CA-4 (1/79)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: November 21, 1979

Project Title: "Water Treatment Equipment Testing Related to Borangay Water"

Project No: E-26-649 (sub-project of B-538/Potts/EEL)

Project Director: T.F. Craft

Sponsor: National Water Well Association under contract with U.S. AID

Agreement Period: From 8/8/79 Until 12/31/79

Type Agreement: Letter subcontract from National Water Well Association

Amount: $72,654 ($53,502-B-538) and ($19,152-E-26-649)

Reports Required: Final Report

Sponsor Contact Person (s):

Technical Matters

Contractual Matters
(thru OCA)

Dr. Jay H. Lehr
Executive Director
National Water Well Association
500 West Wilson Bridge Rd.
Worthington, Ohio 43085

Defense Priority Rating:

Assigned to: NE (~~School~~/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
Dean/Director—EES
Accounting Office
Procurement Office
Security Coordinator (OCA)
Reports Coordinator (OCA)

Library, Technical Reports Section
EES Information Office
EES Reports & Procedures
Project File (OCA)
Project Code (GTRI)
Other OCA Research Property Coordinator (C.E. Smi

CA–3 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: 3/9/81

Project Title: "Water Treatment Equipment Testing Related to Borangay Water"

Project No: E-26-649 (sub-project of B-538/Potts/EEL)

Project Director: T. F. Craft

Sponsor: National Water Well Association under contract with U. S. AID

Effective Termination Date: 4/14/80

Clearance of Accounting Charges: 4/14/80

Grant/Contract Closeout Actions Remaining:

None -- See B-538

- _ Final Invoice and Closing Documents
- _ Final Fiscal Report
- _ Final Report of Inventions
- _ Govt. Property Inventory & Related Certificate
- _ Classified Material Certificate
- _ Other ____________________

Assigned to: Nuclear Engineering (~~School~~/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
Dean/Director–EES
Accounting Office
Procurement Office
Security Coordinator (OCA)
~~Reports Coordinator (OCA)~~

Library, Technical Reports Section
EES Information Office
Project File (OCA)
Project Code (GTRI)
Other OCA Research Property Coordinator

CA–4 (1/79)

DISCLAIMER:

This document has been proofed and
its original formatting has been retained.

Water Treatment Equipment Testing
Related to
Barangay Water Program

WATER TREATMENT EQUIPMENT TESTING RELATED TO BARANGAY WATER PROGRAM

Prepared for
The National Water Well Association

by
T. F. Craft, Ph.D.
School of Nuclear Engineering

and

Henry Van, Ph.D.
International Programs Division
Engineering Experiment Station

GEORGIA INSTITUTE OF TECHNOLOGY
Atlanta, Georgia 30332
April 1980

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

SUMMARY

Two teams of investigators sought sites in the Philippine Islands where selected water-disinfection devices could be installed for evaluation. Selection criteria were based on the need for disinfection, technical, political, and logistical considerations. The first team explored many areas and locations and found only one place where the technical and other requirements matched the capability and capacity of one of the devices. An iodinator was therefore installed at Agsalanan, Iliolo Province.

The second team investigated additional possible locations and reevaluated some of the sites previously visited. No additional places appropriate for equipment installation were found. A follow-up visit to Agsalanan verified the proper functioning of the iodinator. An inexpensive hypochlorinator was constructed of locally obtained materials and was found to operate satisfactorily.

It is concluded that the specific disinfection devices which were to be evaluated are not suitable for conditions existing at most locations in the Philippines at this time. It is possible that one or more of them might have utility if installed during the construction or reconstruction of a system, but retrofit to existing systems is not practical.

CHAPTER 1

INTRODUCTION

In accordance with the terms of the contract existing between the National Water Well Association and the Georgia Tech Research Institute, water-disinfection devices and supplies were purchased and shipped to Manila, Philippines. It was planned that the devices would be installed at selected appropriate sites, calibrated, and put into operation. A program of monitoring and evaluation was to be established to determine the worth of each device under field conditions. These preceding tasks could be performed in conjunction with the Barangay Water Project and in cooperation with the Ministry of Local Government and Community Development (MLGCD).

The Barangay Water Project (BWP) is a program designed to provide potable household water to small rural farming and fishing communities in the Philippines. Since the communities are small, the water systems are also small and generally consist of developed springs or wells, storage facilities, and transmission lines and laterals. Water is delivered to consumers through strategically placed public faucets or individual house connections. The type and size of the projects vary from community to community, but some characteristics are common to all systems: they are owned, maintained, and managed by the users themselves through water service cooperatives.

With 42,000 small rural communities representing 20 million Filipinos largely outside the jurisdiction of water systems in the Philippines, the nation lacks a central agency with sufficient resources or organizational outreach to satisfactorily diminish the magnitude of the water problem. Therefore, the BWP works through local officials and provincial or city governments in an effort to develop their capabilities to plan and install village-owned water systems.

The United States Agency for International Development (USAID) provides loans and advisory and engineering services to the Philippine Government (GOP) to successfully implement the project. The purpose of these loans is to assist the GOP in refining the process of domestic water delivery and in institutionalizing the program at the national and local levels. This effort prepares communities for larger funding inputs from AID and other international donors.

At present, organizational structures are established in the Philippines which range from the national to the provincial government level. This structure is staffed with trained personnel who develop detailed systems to construct and organize water systems. Both a national office and 29 local government units are currently participating in the program. Prior to the AID loan, five pilot projects were constructed using GOP funds. An additional 133 village systems are being constructed between 1979 and early 1981.

In November 1979, the first Georgia Tech team arrived in the Philippines to survey BWPs existing community water systems in cooperation with staff members of USAID/Manila and personnel from the Ministry of Local Government and Community Development. Details of the first team's visit are outlined in Chapter Three titled "Site Selection". Chapter Five describes the activities and results of the second team's visit in February 1980.

CHAPTER 2

EQUIPMENT

The devices to be tested were specified in the contract as follows:

- Katadyn Filter MF-7R manufactured by Katadyn Products Ltd., Switzerland
- Walbro Total Water System manufactured by Water Pollution Control Systems Corp., Ann Arbor, Michigan
- Iodinators (Models #5 and #8) manufactured by Iodinamics Corp., El Paso, Texas
- Hypochlorinators (Models Water-Sure 050 and Water-Sure 152) manufactured by World Water Resources, Bethesda, Maryland

The four most significant parameters for each item are listed in Table 1. It may be seen here that a pressure of 25 pounds per square inch (psi) or more is required except in the case of the Water-Sure 050 which is designed for noncontinuous operation. Maximum flow rates are 30 gallons per minute (gpm) or less.

Considerable literature was supplied by the various manufacturers and is reproduced here in Appendix A. Some of the material is descriptive; other literature gives detailed installation and operating instructions. Accompanying instructions seem clear to a reader with a reasonable facility in English. However, it is not known if these instructions are sufficiently clear and detailed to allow ready adoption by less highly trained technicians who might install this equipment.

TABLE 1
OPERATING CHARACTERISTICS OF DISINFECTION DEVICES

Device	Minimum Pressure Required (psi)	Maximum Flow Capacity (gpm)	Electricity Required	Comments
Katadyn Filter MF-7R	75*	3	No	High head loss across filter
Walbro Total Water System	30	5	No	Instant disinfection
Iodinamics Iodinator				
Model #5	25	10	No	
Model #8	25	10	No	
World Water Resources Hypochlorinators				
Model WATER-SURE 050	1.3	20	No	Designed for noncontinuous discharge
Model WATER-SURE 152	30	30	Yes	

*Estimated value

CHAPTER 3

SITE SELECTION

CRITERIA

The initial field activity was site selection which began with a meeting of the investigators from Georgia Institute of Technology, staff members of USAID, and personnel from MLGCD.

The USAID representatives provided information about existing and planned water supplies from their long experience in the Philippines and their present involvement in BWP. The MLGCD personnel are in charge of water supplies throughout the Philippines. From this perspective, MLGCD staff are clearly conversant with conditions at many locations, including both BWP and a large number elsewhere.

Consideration was given to the technical, psychological, and political factors that are involved in a site selection, and the following criteria and goals were established.

1. A need for disinfection of the water supply must exist. The addition of any disinfecting device to a system delivering water of acceptable quality would produce little information of value that could more readily be obtained in laboratory evaluations. If any new treatment was added, it would confuse consumers who had been told previously that

their supply of water was good. Raising questions about the water might lessen consumer confidence in the water and health authorities.

2. Hydraulic and physical factors must be appropriate for the device to be installed. It would be ideal to have conditions fall within the middle range of relevant operating parameters. However, conditions should satisfy limits indicated by the manufacturers. Volume and pressure are the prime factors to be considered. Physical arrangements must be flexible for the equipment without the necessity of major facility modification or construction. Electric power must be available.

3. The site should be reasonably accessible. Remote areas reached with great difficulty would make follow-up monitoring so time-consuming as to be completely impractical.

4. The authorities must be both agreeable and cooperative. It would be impossible to install and monitor equipment without the permission of the local authority.

5. Any installation must be acceptable to the consumers served by the system. Actions which would displease the consumers or cause doubt or worry would be a handicap to the project. Due consideration must be given to the public reations for the field activity.

6. If proven successful during the evaluation period, the equipment would continue to be used for disinfection of the water supply. This involves local responsibility for equipment operation and maintenance. Some reliable provision for a continuing supply of the required chemical must be made. Any equipment that remains in operation over an extended period of time would provide the opportunity for additional evaluation at some future date.

GENERAL CONSIDERATIONS

Following the establishment of these criteria, it was clear that site selection would be difficult primarily due to the scarcity of locations where disinfection is either needed or is a priority. Technical requirements of the various devices such as flow capacity, water pressure, and practicality of installation and resupply eliminated a large number of sites.

Personal inspection of possible sites was required and a series of trips were planned. Each type of prevalent water system in the Philippines was inspected, and different sections of the islands were visited. Trips were made to the provinces of Bataan, Cavite, and Batangas, on the largest, northern island of Luzon. Other islands visited included Mactan, the centrally located islands of Cebu and

Panay and the southern island of Mindanao. Each trip had a specific location as its goal. But all sites of possible interest along the itinerary were viewed and photographed providing an expanded overview of water supply matters on the islands.

Discussions were held with governors of two provinces, numerous provincial engineers and planners, and other officials in order to expedite the location of suitable sites. This contact allowed an evaluation of the local receptiveness to the practice of water disinfection. At the lower government levels, contact was made with mayors, councilmen, water superintendents, barangay captains, other officials, and many citizens. Where pollution problems were recognized, suggestions for corrective action were enthusiastically and cheerfully accepted. On several occasions, disappointment was expressed by the local residents when a certain system did not fit the equipment.

SYSTEM TYPES AND SUITABILITY OF EQUIPMENT

The capabilities of the tested devices limited the search for sites to small water systems. These may be categorized as follows:

Ground-Water Sources

Deep wells (200-400 feet) are the source of water for most small communities and are usually much preferred over other sources. Typically the water from deep wells is of very acceptable bacteriological quality, although some pollution becomes evident, as indicated by the development of turbidity, at some locations during the rainy season. Shallow wells are also used when necessary. These wells may provide very good water but are more susceptible to pollution than deep wells.

Most well pollution is caused by infiltration of low-quality surface water from poor construction or improper maintenance of the well or both. While disinfection is useful during periods of pollution, improvement of the well is the long-range satisfactory solution. Common repairs include properly sealing (or resealing) the well casing, paving an area around the well, and sloping the ground down from the pump so that excess water will drain away.

Hand-operated pump As long as the water delivered by the pump is of acceptable quality, there is no urgent need for disinfection. However, a treatment process that provides a residual of active disinfectant is advantageous. This gives some protection against pollution of the water after its collection at the pump. Additional education for consumers in the sanitary handling of water is also needed.

None of the equipment to be tested was designed for use on hand pumps, and direct attachment to a pump was ruled out. Alternate arrangements considered included a disinfector placed near a pump so water could be poured through it. This arrangement requires operation at atmospheric pressure with very little head loss.

The WATER-SURE 050 meets the pressure and low head loss requirements but could not be used for other reasons. Proper operation of the WATER-SURE 050 is not possible when only small quantities of water are poured through it at intervals, a situation typical of hand-pumped supplies. It requires the use of calcium hypochlorite pellets or tablets which could not be located in an extensive telephone search in Manila. Two companies stated that the tablets would require 90 days for delivery. This lack of calcium hypochlorite in pellet or tablet form in the Philippines eliminates the use of the WATER-SURE 050 from a practical standpoint.

The concept of the Walbro Total Water System is attractive, since only momentary contact of the water with the disinfectant Triocide® is needed. However this particular unit is not suited for hand-pumped supplies as it requires a minimum pressure of 30 psi for satisfactory operation. A newly designed device is now recently available that operates under very low pressure and in pour-through circumstances.

The simplest alternative to any commercial equipment is to arrange for the consumer to add a small amount of disinfecting solution to each container of water collected. Instructions on the coordination of disinfectant strength and size of spoon or dipper would be needed. This procedure is widely used in emergency situations around the world as an alternative to sanitization by boiling and is usually practiced for short periods of time.

<u>Power-driven pump</u> The simplest type of power-pumped system consists of a well, a pump, and a storage tank which may be either elevated or placed at a sufficiently high point. Consumers obtain water directly from the tank through faucets as shown in Figure 1. Garden hoses are also used as shown in Figure 2 to fill larger containers which are too heavy to carry by hand. These containers are transported by some type of vehicle.

In the next stage of improvement, water is piped from the tank to public standposts situated at appropriate points. The final stage of development is to pipe water to individual houses.

The need for disinfection in small systems depends on the individual situation. Properly constructed deep wells produce water of very acceptable bacteriological quality.

Figure 1. System providing water directly from an elevated storage tank.

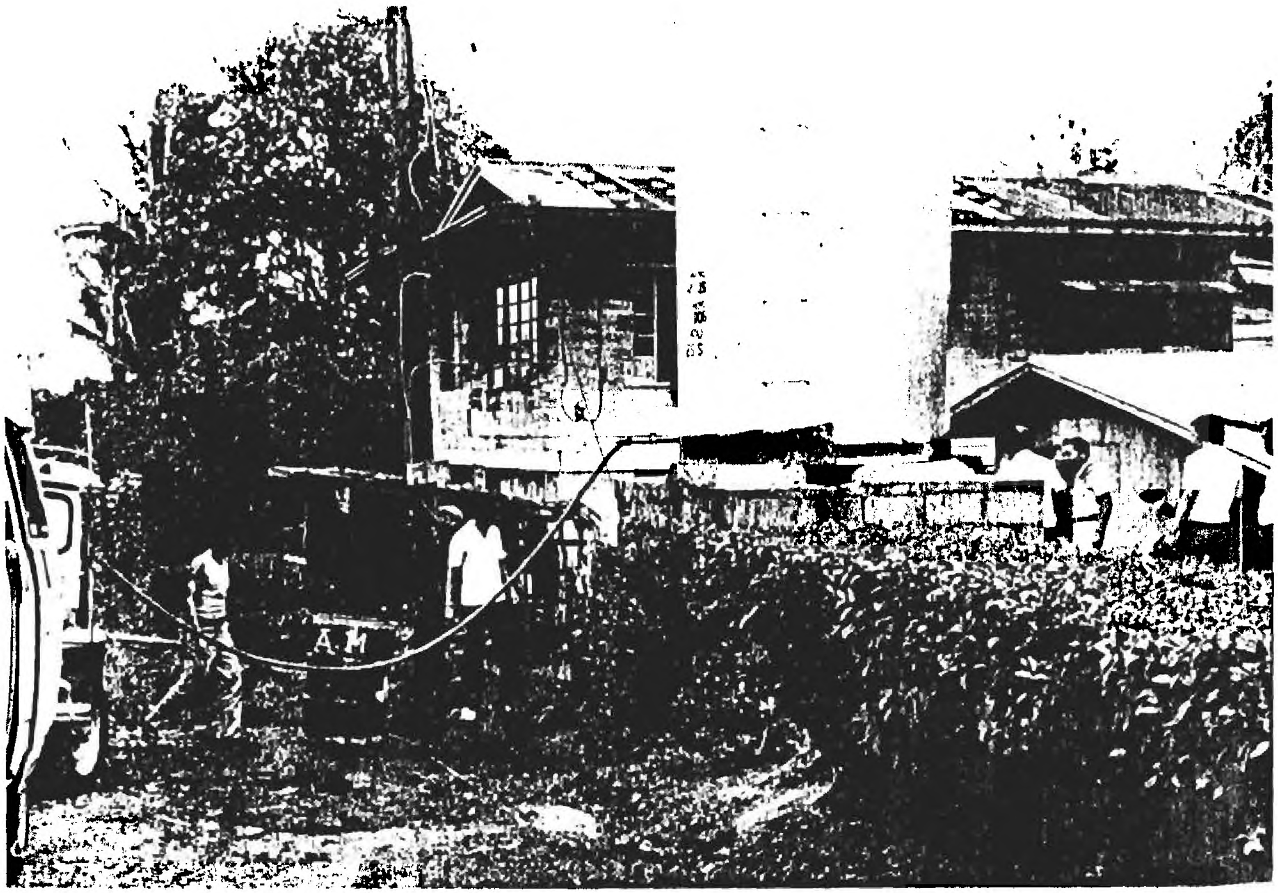


Figure 2. Filling a drum loaded on a Jeepney with a garden hose.

No significant degradation occurs during passage through a closed storage tank. The quality remains acceptable in small distribution systems where high pressures are maintained preventing inflow of external water where the pipe is submerged. It is also necessary to have sufficient flow through the system to keep the pipes flushed. Neither of these conditions prevailed in many of the locations inspected.

Disinfection is a genuine need in piped-distribution systems and is desirable in systems where water is drawn directly from a storage tank or from a hand-operated pump.

It is obvious that the tank is the optimum location for the addition of any disinfectant, and here the possibility of equipment installation is considered. The high pressure and high head loss characteristics of the Katadyn MF-7R Rule out its use. An Iodinamics Iodinator could be installed in the line leading from the pump to the tank, but it is uncertain if the specific situations examined satisfied minimum pressure requirements. Water is pumped to a height of about 15 feet into the tank. With the short run of pipe, the pressure is not very high. Also, the cost of iodine used in the Iodinamics system is very high. Maintaining an iodine supply route could be prohibitive.

The capacity of the Walbro Total Water System makes it unsuitable for these situations even if the pressure requirement of 30 psi minimum is met. The WATER-SURE 050 could probably be installed on the top of a concrete tank if the water pipe is not sealed in the tank side or top. During construction, it would be possible to provide a higher inlet pipe so water could flow into the device from above, pass through, and then fall into the tank through a suitably located opening. A retrofit is considered quite impractical due to the necessity of rearranging pipes and constructing a new opening in the tank top. Additional obstacles in adopting the Walbro system include the low capacity (30 gpm) and the unavailability of calcium hypochlorite tablets or pellets beyond the five pounds supplied with the unit. Local authorities pointed out the unrealistic investment of time and effort in a short-term project that would provide no significant, continuing benefit to the consumers.

The WATER-SURE 152 was also considered for installation. This chemical-feed pump could readily feed hypochlorite or other solutions into the inlet pipe of the tank or the tank itself. If wired into the same circuit as the pump, it functions only when the water pump is operating. This promotes a uniform level of hypochlorite addition even if power failure occurs.

The WATER-SURE 152 system is equipped with a device for dissolving and maintaining a container of calcium hypochlorite solution to supply the chemical-feed pump. Dissolver specifications call for a minimum operating pressure of 35 psi in the water supply line, a condition not encountered in the areas surveyed. The dissolver also requires tablets or pellets of calcium hypochlorite which, as noted above, are unavailable. A simpler method would be to supply the chemical-feed pump from a plastic container of several gallons of hypochlorite solution. The solution is made by dissolving powdered calcium hypochlorite and stirring by hand. An auxiliary container might be more convenient for preparing the solution which would then be poured into the hypochlorite supply container. Liquid bleach or sodium hypochlorite solution are also widely available and would be easier to mix for use.

Another option is the use of a locally built hypochlorinator, perhaps similar to the floating-bowl type shown in Figure 3. Several variations of this general type of device are described and illustrated in Appendix C. At an estimated construction cost of less than $25.00 (U.S. currency), the unit is placed on top of a tank and provides a constant flow of hypochlorite solution by gravity. Like all other solution feeders, it would require daily attention.

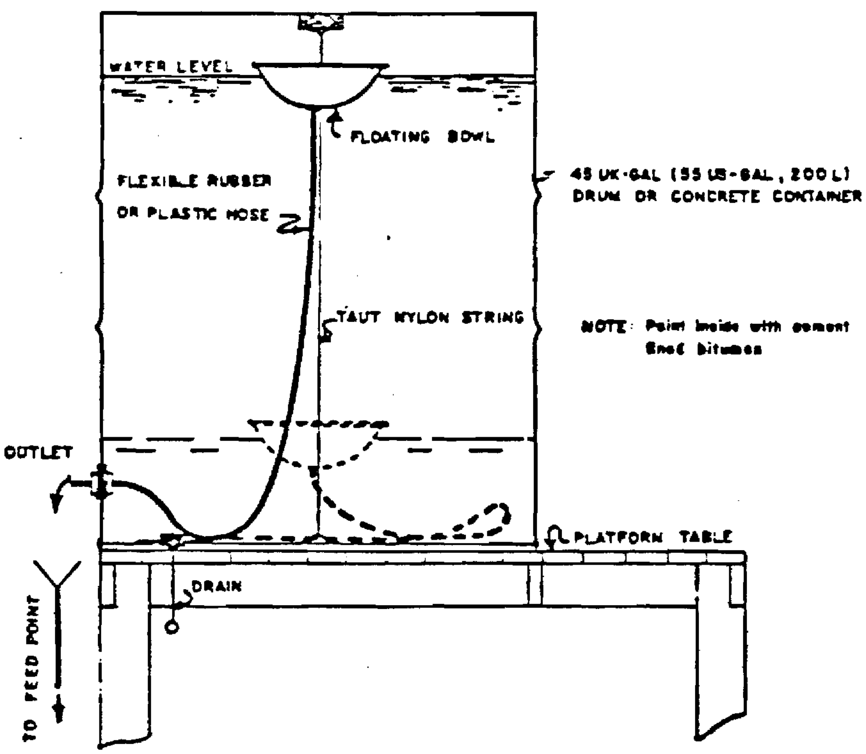


Figure 3. Floating-Bowl Solution Feeder

Surface Water Sources

Hand Carried Streams or springs may be used as water sources where water is collected in containers and carried to the point of use. Surface sources are more prone to pollution and are generally considered bacteriologically suspect. In some locations, a stream serves as a standby to a well and is used when the well is inconveniently located or dries up or when the pump fails. The established need for disinfection of water collected by hand from surface sources is accomplished in the same manner as described above for water obtained from hand-operated well pumps.

Gravity-Feed Where the situation and terrain permit, streams or springs are equipped with catchments (dams or boxes) that allow gravity flow to communal standposts or individual houses.

The obvious location for disinfectant addition is at the point of collection. However, this is where the minimum pressure in the system is found and only in exceptional cases will a device requiring significant pressure be useful. The water supply of the village of Agsalanan on the island of Panay was found to have the proper combination of characteristics for the installation of an iodinator. Details are given below.

Power-pumped supplies Water from surface sources is clearly present. The same considerations pertain as detailed previously.

CHAPTER 4

INSTALLATION OF IODINATOR AT AGSALANAN

Three springs constitute the water source for the village of Agsalanan. The water is collected at each spring and piped downhill to a storae tank which is a cube of approximately three meters. The general arrangement is shown in Figure 4, and a sketch of the tank is given in Figure 5. Tank capacity is apprxomiately 22,800 liters (6,000 gallons), and the rate of flow from the springs is about nine gpm. The population served by this water system is 656. Using an elevated design, the concrete tank rests on legs approximately 75 cm above the ground. The rationale for this design is not clear, as the tank could be located at a slightly higher elevation up the hill and placed solidly on the ground. This configuration provides an exposed, vertical section of two-inch pipe which carries water from the tank to the consumers at lower elevations.

The installation of the Iodinamics Model 8 Iodinator was accomplished by cutting out a section of pipe and replacing it with the same length of pipe section. This assembly consisting of a pipe nipple and valve had previously been assembled from a gate valve and two short pieces of pipe. One-quarter inch pipe nipples were welded into the two-inch pipe with one on each side of the valve.

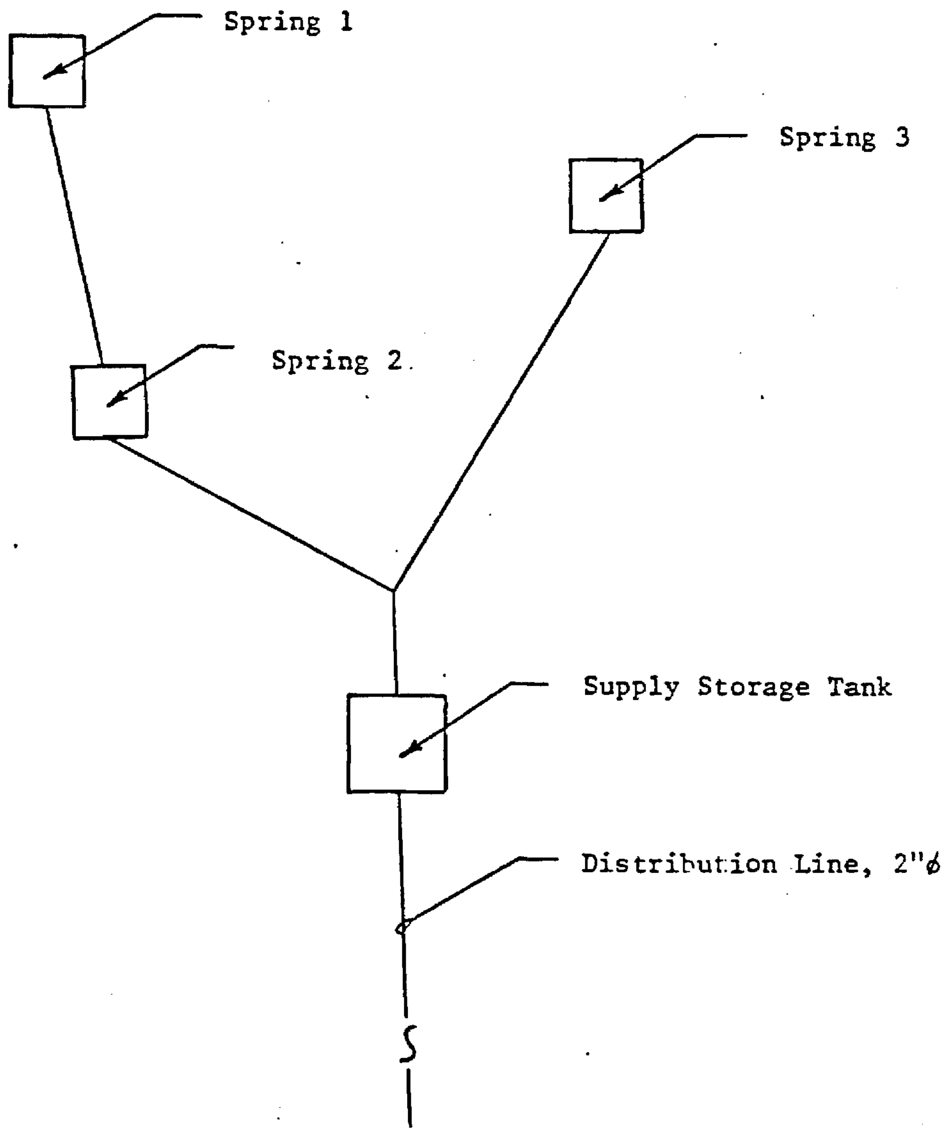


Figure 4. Agsalanan Water Supply System

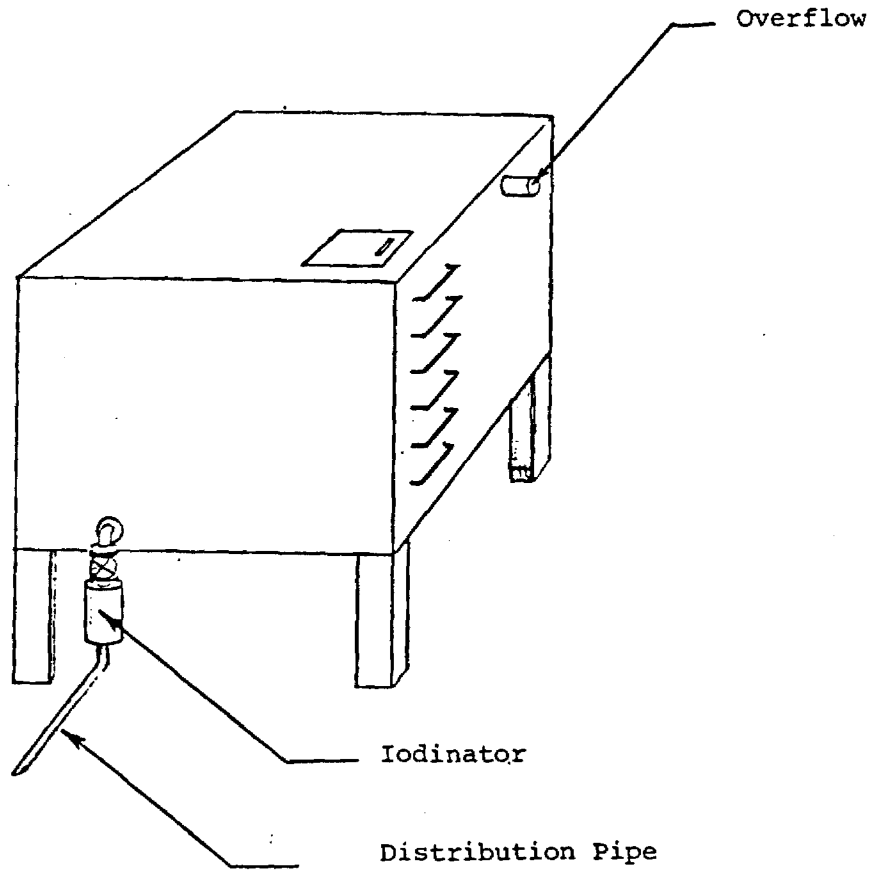


Figure 5. Agsalanan Water Storage Tank

The assembly was disinfected by soaking in a strong solution of sodium hypochlorite and then secured in the line with sections of heavy rubber tubing held tightly in place with stainless steel clamps. The leads to and from the iodinator were attached to the small nipples. The main valve from the storage tank was not closed until everything was prepared and the exact location of the hacksaw cuts were clearly marked. Due to the determined efforts of very willing helpers at Agsalanan, the entire process was carried out quickly, and flow from the tank was resumed in 12 minutes. The iodinator is enclosed in a locked, wooden box in an effort to discourage vandalism or unauthorized tinkering (see Figure 6).

Flow through the iodinator occurs only when there is sufficient head loss in the section of the main pipe between the iodinator connections. This head loss is provided by throttling down on the newly installed valve. Tests for iodine residual were incrementally made at the first consumer standpost with a residual of approximately 0.7 mg/l eventually obtained. The system was checked again the following day at the same point and at several distant points. In each case, the residual had the same value.

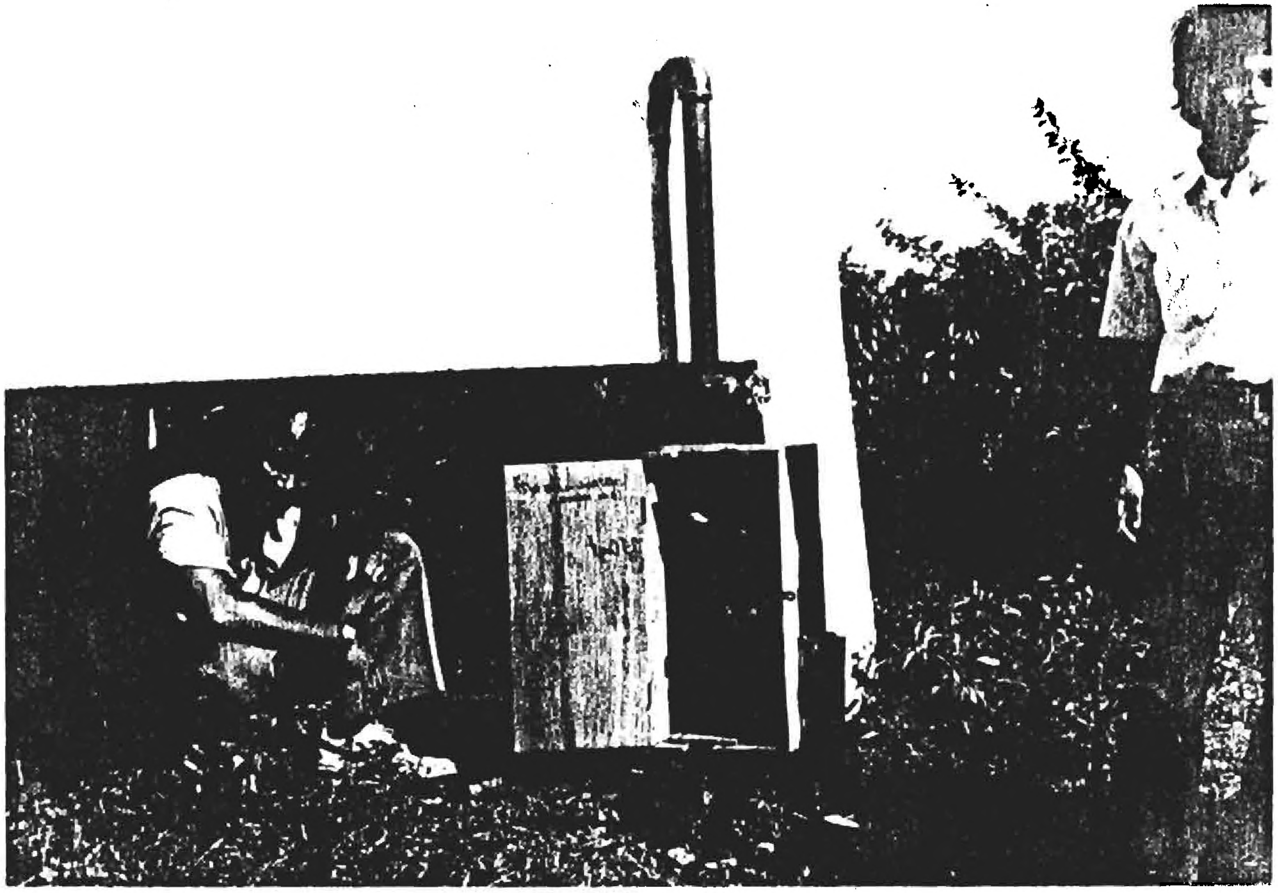


Figure 6. Iodinator installed at Agsalanan

CHAPTER 5

SECOND SITE SEARCH

Initially a meeting was conducted to review previous activities performed by the first Georgia Tech team in November-December 1979 and consider the first team's findings. It was agreed to visit some of the previous sites to acquaint the second team with the existing conditions and examine other sites. The same general site selection criteria, described earlier, were used by the second team.

During the initial meeting of the second team at the request of USAID/Manila, the understanding was established that the testing program would take place within BWP sites. However, because the BWP is in its initial stages, the number of operational systems is minimal, the capacities of the devices to be tested are low, and the limited need for disinfection decreases the number of possible sites. Local health authorities and USAID staff have tested a majority of those systems and found the water bacteriologically safe (negative Escherichia coli). During this investigation, bacteriological quality of the water at the sites visited was assessed.

Each bacteriological analysis of water consists of testing for coliform bacteria. While not themselves disease producers, these bacteria are often associated with disease-causing organisms and are a good index of the degree of bacteriological safety of water. Coliform bacteria normally occur in the intestines of humans and other warm-blooded animals and are discharged in great numbers in human and animal wastes. In polluted water, coliform bacteria are found in densities roughly proportional to the degree of fecal pollution. Therefore, coliform bacteria serve as indices of such contamination. The technique employed for the bacteriological analysis of water samples at the BWP sites is the membrane filter method described in the 14th edition of Standard Methods for the Examination of Water and Wastewater.

Due to the long distances to the sites, operational time was consumed very rapidly. The required traveling time ranged from a one-way minimum of three hours by car to a one-hour flight plus a two-hour car ride. This shows that accessibility played a major role concerning the timetable.

Investigators met with the governor of one province and various provincial engineers and planners in an effort to find suitable testing sites. The following six sites were visited, and water was tested for bacteriological (total coliform) content.

AGSALANAN

Agsalanan is the site of the iodinator installation. The level in the iodinator three months after construction by the first team was less than one third full. Samples were taken at two locations, the nearest and furthest from the water storage tank, and tested for iodine residual and total coliform count. The iodine residual was 0.3 parts per million (ppm), and total coliform colonies were too numerous to count.

The fact that the iodine level was so low surprised investigators, since the supply provided in November 1979 should have lasted about two more months. In light of this finding, an investigation was conducted to find the cause of the rapid consumption of iodine. The investigation showed that six of the twelve faucets in the village were broken, and iodinated water was continuously being wasted. This problem was promptly reported to the provincial engineer who immediately installed new faucets. The iodinator was resupplied with iodine and calibrated to provide a 0.7 ppm iodine residual. At this residual, total coliform counts were negative. This shows that due to the high degree of contamination of the water source, the low residual and the minimal contact time prevailing earlier in the system were together not sufficient to accomplish a high percent kill. Therefore, a higher concentration of iodine was needed.

Taking advantage of the opportunity, a test floating-bowl hypochlorite solution feeder was built as a result of local government officials interest in knowing what type of disinfection device could be substituted in case the iodinator did not work or the iodine supply was scarce. This device is a simple hypochlorinator made from locally available materials according to the plan of Figure 3 at a cost of $17.70. Calcium hypochlorite powder can be puchased at $1.41 per pound.

The floating-bowl chlorinator was installed and calibrated to provide 0.5 ppm residual at the furthest sampling point. Water was tested for total coliform bacteria and chlorine residual. Each coliform count was negative. At the most distant point, the chlorine residual was 0.5. Construction, installation, and operation of this chlorinator presented no major problems.

CAVITE PROVINCE

This site was visited by the first team. However, at that time the water storage tanks had not been constructed. The site was composed of three different villages, each with its own water storage tank and distribution system. These are described below.

Buna Lejos Village

This water system has two concrete water storage tanks serving a population of approximately 2,100 people. Each tank has a capacity of 4,000 gallons. The source of water is a deep well with an approximate pumping level of 200 feet. Water is pumped by an electrical pump at the rate of 32 gpm. Figure 7 shows the tank arrangement. Both tanks were properly coated and sealed to prevent water contamination.

Water samples were taken on two different occasions and analyzed for total coliform content. Results were negative for *Escherichia coli*, indicative of fecal contamination. The growth on the plates was mostly *Aerobacter aerogenes* and other aerobic, gram-negative bacteria, not necessarily indicative of fecal contamination. These results indicated no need for disinfection.

Buna Lejos Elementary School

This water system has one concrete 4,000-gallon water storage tank supplied by a 35 gpm electrical pump serving approximately 600 people. The water source is a well approximately 200 feet deep. Figure 8 shows the tank arrangement. Water was tested for coliform bacteria on two different occasions with negative results. Consequently, there was no need for disinfection.

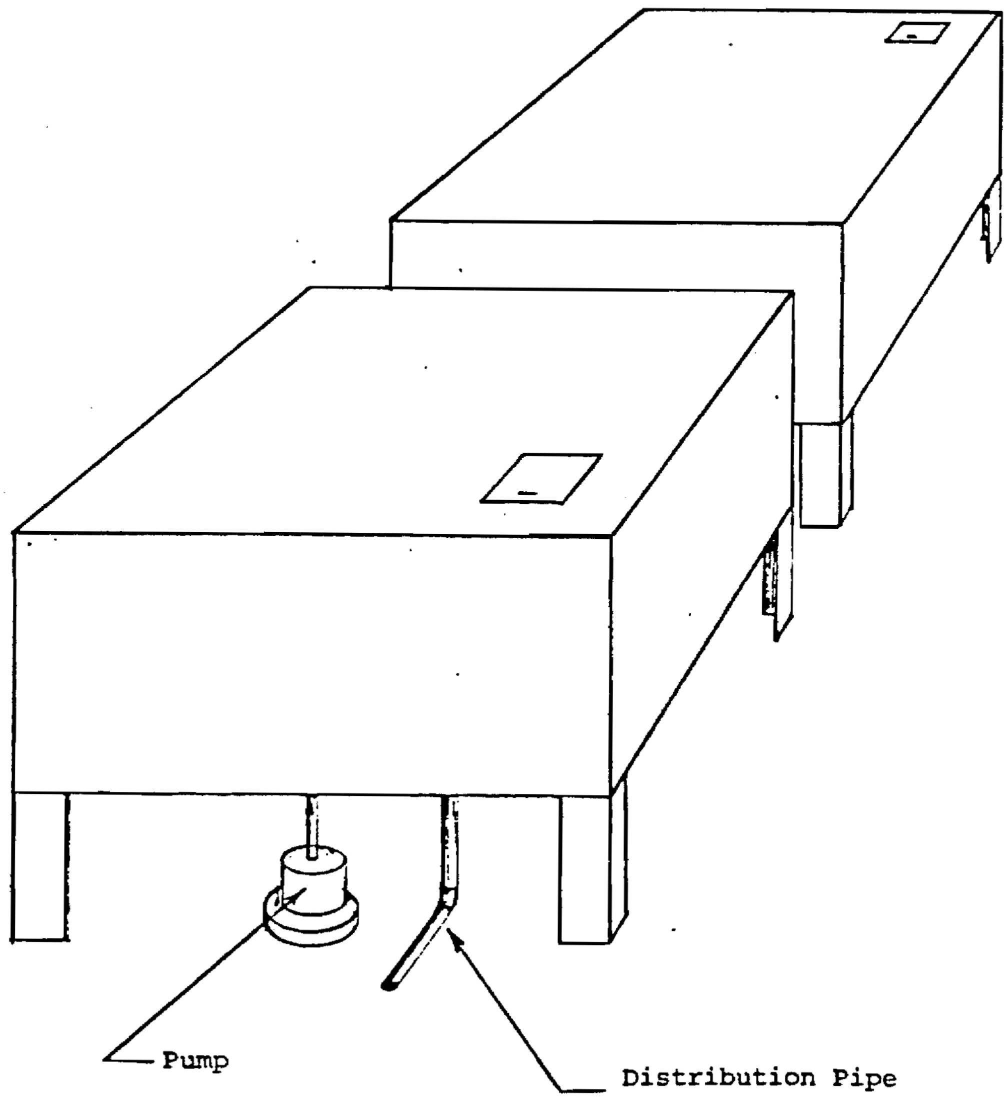


Figure 7. Buna Lejos Water Storage Tank

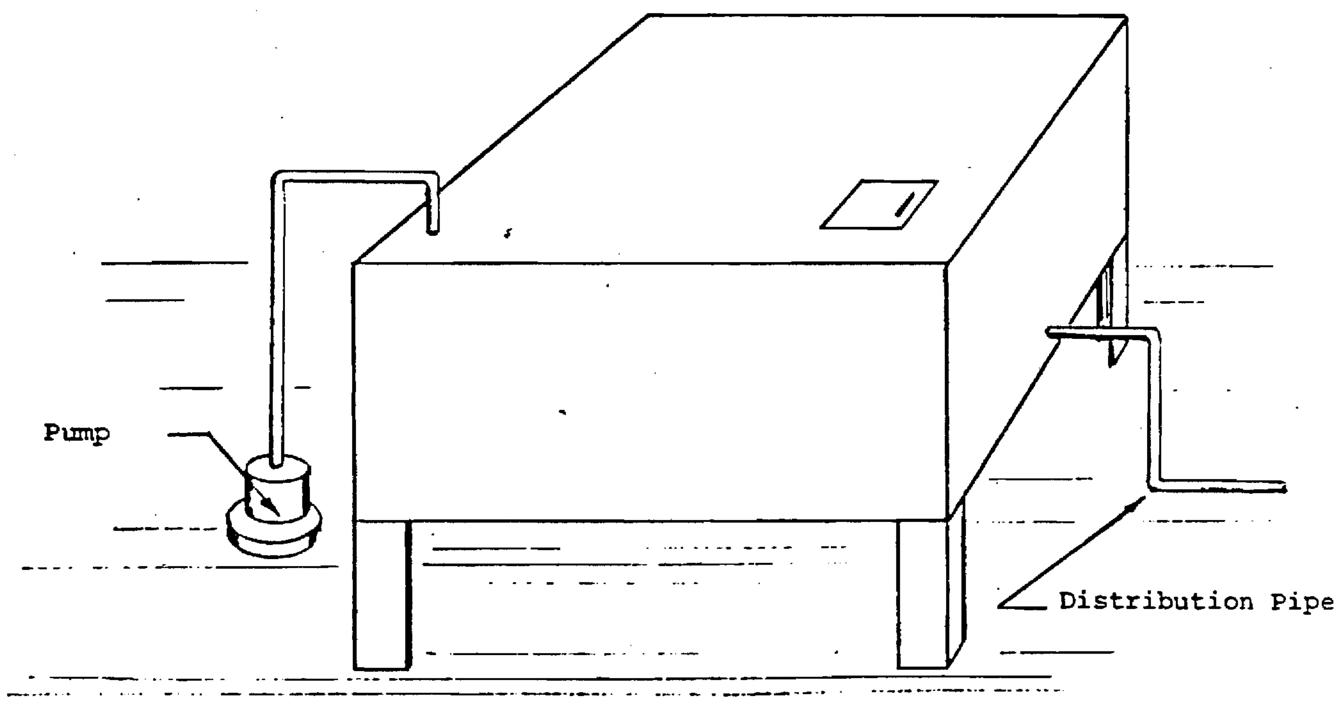


Figure 8. Buna Lejos Elementary School Water Storage Tank

Talon Village

One concrete 6,000-gallon water storage tank supplied by an 18 gpm electrical pump serves as the water system. The water source is a well about 250 feet deep. Approximately 1,440 consumers are served in this water system. The water was bacteriologically tested and the results obtained were identical to the other two locations. Therefore, no disinfection was required.

The water tank arrangement in Talon Village is similar to the one in Buna Lejos Elementary School. Since these systems are new, little bacteriological quality data is available. However, BWP personnel are reviewing this parameter for new disinfection when an appropriate device would be installed and monitored.

Mabayo

This village of 1,000 is located in Bataan Province. Village residents constructed a handmade retaining wall across a nearby, small stream to collect water. A two-inch pipe transports the water by gravity to the village where several public faucets are available to the people. Figure 9 shows the dam and spillway arrangement.

The provincial engineers have been wanting to incorporate this village into the BWP. By becoming a member

Figure 9. Dam and spillway at Mabayo, Bataan.

of the BWP, a safe water system can be constructed. However, for a village to become a member of the BWP, AID requires a 90 percent resident approval. A survey was conducted in Mabayo, and results showed that only 78 percent approved.

A bacteriological analysis of the water was conducted, and results showed considerable Escherichia coli contamination and a need for disinfection. In the future, if this village gets the 90 percent resident approval, AID/Manila will select an appropriate disinfection device and install it.

Rosario

A group of people in this village in Cavite Province expressed their desire to have safe drinking water to a BWP engineer. Since only one disinfection device, the iodinator, has been installed during this research effort, AID/BWP officials diversified the testing procedure by installing a Walbro Total Water System (TWS). Approximately ten houses are served by a hand-operated water pump. Bacteriological analysis of the water source showed a considerable number of Escherichia coli. The well is surrounded by latrines and a cemetery. Assembled and mounted on a wooden frame, the TWS is approximately 24

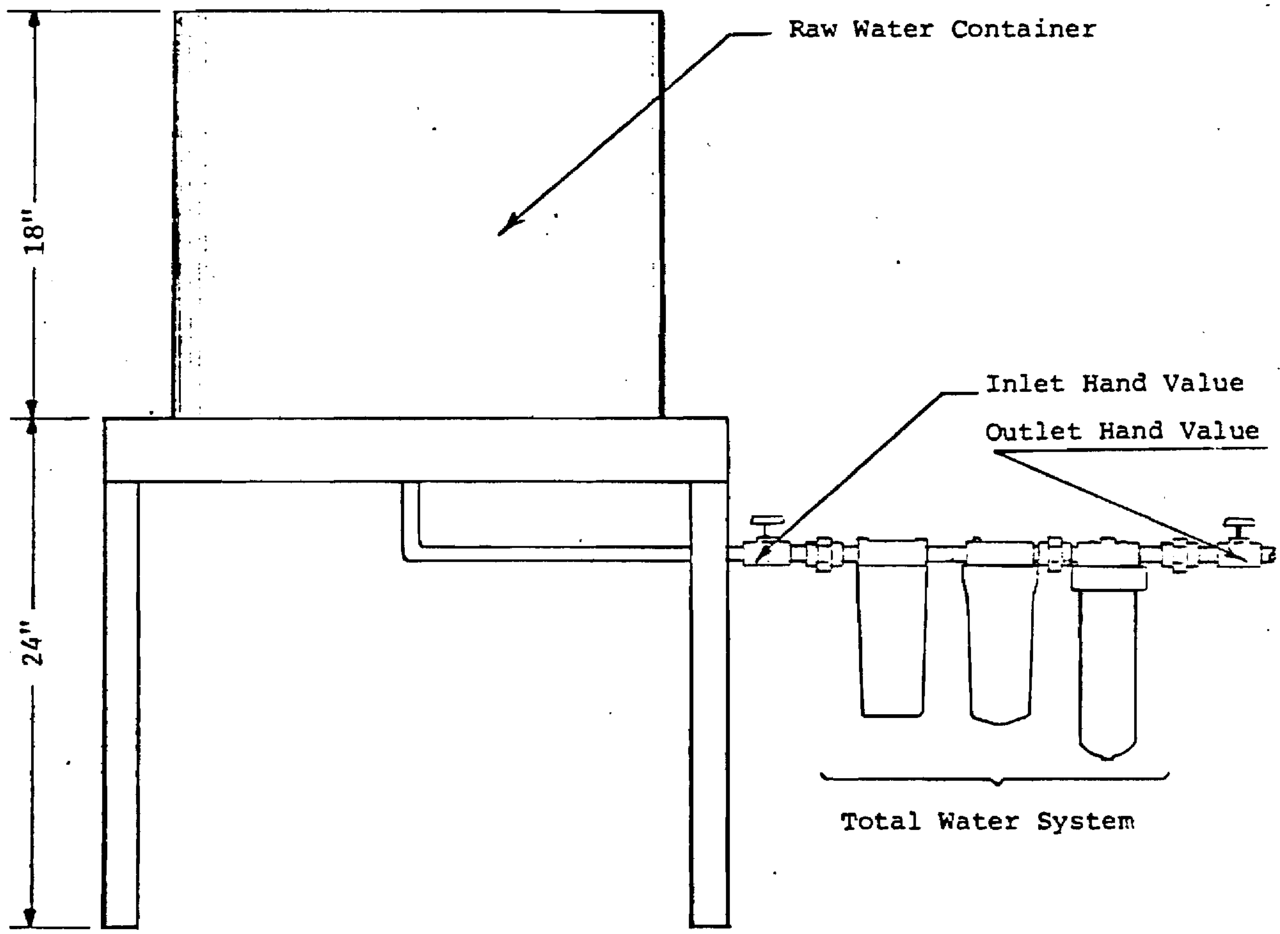


Figure 10. Walbro Total Water System in Rosario, Cavite.

inches from the ground. Figure 10 depicts the Walbro Total Water System arrangement. Water is poured in a bucket connected to the two filters and one disinfectant cartridge. The hydraulic head acting on the water through the cartridge is only 18 inches, and the flow is minimal due to the very low pressure. The treated water is used only for drinking purposes. When a person takes a certain amount of water for personal use, the same amount is replaced in the raw water bucket. Bacteriological analysis of the treated water shows no growth of coliform bacteria. Residents are very appreciative of the fact that they can drink clean water. The stated minimum required pressure for this system is 30 psi. However, this unit does not meet this requirement. The flow of water is very small, but the people, because of the need for safe water, are willing to wait for the bucket to fill up. They were told that the Walbro Total Water System would be provided only for the study test period. BWP personnel will continue to monitor this system and collect data.

Conclusion

The above six sites are the ones visited during the second team's visit to the Philippines. Due to the exhaustion of available operational sites within the BWP, the investigators decided there would be no value in staying longer in the Philippines. However, AID/Manila stated that as new water systems are developed, the need for disinfections will be established. As demands for disinfection grow, the most appropriate devices will be installed.

Appendix C shows various types of chlorinators and solution feeders which have been used in developing countries. These diagrams were obtained through a literature survey in an effort to discover what other types of chlorinators and solution feeders are considered appropriate by other authors.

A survey of the local market for disinfection devices, the logistics for supplying the devices under study, and the resupply of disinfectant and spare parts are discussed in the following chapter.

CHAPTER 6

MARKET SURVEY

To better assess the availability of local disinfection equipment, disinfectant, and spare parts in the Philippines, a survey was conducted by calling every company which advertised this type of equipment in the telephone directory.

Table 2 lists the distributors who were contacted and the information obtained. A great number of distributors advertised disinfection devices; however, when contacted, they no longer sold that type of equipment. Most of the distributors in Table 2 have spare parts available, and the Philippine equipment they sell uses powder or liquid chlorine.

Both chlorine and iodine are not manufactured in the Philippines. Each must be imported from other countries, and an import tax of 50 percent must be paid. During the survey, only one distributor was found to sell iodine or any device that uses it.

Table 3 lists the distributors that supply disinfection devices, spare parts, and needed chemicals. The majority of these distributors did not have the items in stock. However, they can make it available within a period of 60 to 90 days from the time of initial order. Prices were not available.

TABLE 2

SURVEY OF DISINFECTION EQUIPMENT, DISINFECTANT, AND SPARE PARTS IN METRO MANILA, PHILIPPINES

A. WARME CHEMICAL CORP.

400 Mayon St.

Quezon City, Philippines

Tel. No. 61-83-65 or 61-69-41

Branch Offices:

- Cebu (Tel. No. 7-50-17)
- Dabao
- Cagayan de Oro

The disinfection equipment, disinfectant, and spare parts available include the following:

1. Regal gas chlorinator
2. Hypochlorinator
    - Chemical Feed Pump Type
    - Water Meter Operated Chemical Feed Pump Type
    - Capacity of hypochlorinators
        - One gallon per hour at $413.79 (U.S. made)
        - Five gallons per hour at $524.14 (U.S. made)
    - German-made hypochlorinators
        - Some models are available with high precision pumps
        - Price range $2,069 - $9,655
    - Powdered chlorine (calcium hypochlorite) is in stock

TABLE 2 (cont'd.)

B. ALPHA MACHINERY AND ENERGY CORP.

Mr. George Aguinaldo, Gen. Manager

1167 Pasong Tamo

Makati, Philippines

Tel. No. 88-34-94 or 86-55-56

This company sells hypochlorinators of two types:

1. Gravity
2. Ratio Feeder

Price ranges from $414 to $1,034. The company has chlorine powder (70 percent available chlorine). Also, the company sells an erosion-type chlorinator which uses chlorine tablets. These tablets are not in stock, (65 percent available chlorine). This device is mainly sold to chlorinate sewage. At the time of the inquiry, the general manager was not available to provide information on prices.

C. CULLIGAN WATER CONDITIONING

Represented by: MACONDRY & CO., INC.

Mr. Mike Aguilar

Fourth Floor, Filipinas Life Bldg.

Makati, Rizal, Philippines

Tel. No. 88-92--07

Branch Office: 256 D. Jakosalem St.

Cebu City, Philippines

TABLE 2 (cont'd.)

Tel. No. 7-40-10

Macondray & Co. carries several types of hypochlorinators of various sizes. Appendix B shows the price list and descriptions for these devices.

D. PALL ROCES CORP.

Mr. Roland Acuna

Ground Floor, Jaycee-Pepsi Bldg.

No. 14 Roces Ave., Quezon City, Philippines

or P. O. Box 1092, Manila, Philippines

Tel. No. 97-38-30

This company sells two types of Canadian-made chlorinators:

1. Gas
2. Hypochlorinators
    - Model WCP 1-15
      - Price $706
      - Capacity 200 gpm
    - Model WCP 1-30
      - Price $734
      - Capacity 200-400 gpm
    - Model WCP 1-60
      - Price $762
      - Capacity 400-600 gpm

These hypochlorinators use either powder or liquid chlorine.

TABLE 2 (cont'd.)

E. VILLONGCO WATER TREATMENT AND CONSTRUCTION CORP.

Prudential Bank Bldg.

Metro Manila, Philippines

Tel. No. 27-34-93 or 27-34-03

This company sells only liquid chlorine at 5 percent available chlorine. The price is $2.07 per gallon.

F. NALCO CHEMICAL CO.

1134-A Antipolo St.

Makati, Metro Manila, Philippines

Tel. No. 89-93-12 or 89-99-61

Although this company specializes in selling water treatment chemicals, it does not sell chlorine or any other type of disinfectants or disinfection equipment.

G. MARGA TRADING INC.

Greenhills Condominium Shopping Center

2063 V.V. Soliven Shopping Center Complex, EDSA

San Juan, Philippines

Tel. No. 79-99-60 or 78-99-61

This company advertises a specialization in water treatment equipment and chlorinators but does not sell disinfection equipment or disinfectant any more.

H. PETER BLAISE CHEMICALS, INC.

2300 P. Tamo Ext. Makati

Metro Manila, Philippines

TABLE 2 (cont'd.)

Tel. No. 86-78-17 or 87-67-19

This company does not sell disinfection equipment or disinfectants.

I. FOOD INDUSTRIES, INC.

Herdis Bldg., 180 Salcedo St.

Legaspi Village, Makati

Metro Manila, Philippines

Tel. No. 86-47-70 or 86-44-15

This company does not sell water disinfection equipment or disinfectants any more. At present, the company sells activated carbon filters only. The trademark of the filters is EVERPURE.

TABLE 3

AVAILABILITY OF PILOT DISINFECTION DEVICES, DISINFECTANT, AND SPARE PARTS IN THE PHILIPPINES

A. WORLD WATER RESOURCES INC.

1. L & S CHEMICAL SUPPLY

Philippine Distributor

Mr. Liberato S. De Jesus

General Manager

109 Rizal Avenue

Tonsuya, Malabon

Metro Manila, Philippines

Tel. No. 23-07-81 to 85

Cable: "Liberato Manila"

P. O. Box 3960, Manila, Philippines

This company has an agreement with World Water Resources, Inc. to distribute chlorine tablets. Chlorine tablets are not in stock but can be supplied in 90 days.

The cost of chlorine in the Philippines must include the following unless waived by the government of the Philippines:

- Import Tax = 50 percent
- Sales Tax = 10 percent

L & S Chemical Supply charges the following prices for chlorine tablets:

- Tablet (65 percent available chlorine)

TABLE 3 (cont'd.)

- One Metric Ton (2,204.62 lb) = $267.03 or $8.26 per pound*
- Fifty Kilogram Packages = $13.35 or $8.26 per pound*

• Powder (65 percent available chlorine)

- Forty-five Kilogram Packages: $11.99 or $8.27 per pound*

*Price does not include import or sales tax.

2. EDWARD J. MELL CO.

Philippine Distributor

Mr. Benjamin T. Sulit

Manager

325 Buendia Ave.

Makati, Metro Manila Tel. No. 87-85-51 to 59

The company handles the WATER-SURE 152 which they are trying to promote. However, at the time of the study, no purchases had taken place. Chlorine tablets are not stocked, but can be furnished in 90 days.

B. KATADYN MICRO FILTRATION DEVICES

1. TECHNOQUIP MACHINERY, INC.

Philippine Representative

Mr. Jesus S. Gutierrez, EM

Marketing - Sales Manager

406 Cattleya Condominium Bldg.

TABLE 3 (cont'd.)

Salcedo St. Legaspi Village, Makati

Tel. No. 87-11-64, 88-05-11

Telex RCA 2536 TIM PH

TECHNOQUIP is a distributor of KATADYN filtration devices. The company has a variety of models in stock, including the MF-7R Water Filter.

Replacement candles are available in stock for the MF-7R at $34.48 each.*

*Price does not include sales tax.

C. IODINAMICS INC. IODINATOR DEVICES

1. MARMOSY TRADING INC.

Philippine Distributor

Mr. Romeo L. Sy

MCC, P.O. Box 1468

Makati, Tizal D-708

Manila, Philippines

Tel. No. 85-73-41 or 87-84-94

Telex No. 7222050

Cable No. "JOMARCA MANILA" VANCE

ET # 8125

Marmosy Trading, Inc. does not have the iodinator or iodine in stock. However, they can make them available in 90 days. A price list was not available in the Philippines.

TABLE 3 (cont'd.)

D. DAVCO TRIOCIDE FILTRATION AND DISINFECTION DEVICES

1. MARUBENI CORPORATION

   Philippine Representative

   Fourth Floor, FEM II Bldg. Aduana St.

   Manila, Philippines

   Tel. No. 491-241 thru 9

   Telex No. 27358

The General Manager was not available. However, USAID/Manila will attempt to contact him for detailed information.

CHAPTER 7

SUBSEQUENT MONITORING AND EVALUATION PROGRAM

MONITORING

Disinfection devices installed under this program should be monitored, and a field cost-effectiveness test should be performed. At this time, it would be difficult to establish a monitoring schedule, since only two devices have been installed. However, when more devices are installed at different sites, the data collection can be justified. Consultants recommend the use of an organized, logical method of evaluating these devices called a "Systematic Procedure for Assessing the Worth of Complex Alternatives."

In the past, economic analysis of engineering systems was based primarily on cost considerations. Least-cost solûtions satisfying fixed requirements/constraints were initially used to compare system alternatives. Economic efficiency was measured by cost minimization without consideration of the total scope of a system's economic impact when in operation. Later, evaluations centered around a net cost or net savings which represented the difference between total cost and any resultant savings or benefits which could be expressed in dollars and cents. Experience has shown, however, that combining costs and benefits into a single measure may not necessarily indicate the most economically efficient alternative. Benefit-cost analyses in some cases may be satisfactory if the benefits are expressed in terms of dollars. However, in evaluating water disinfection systems for use in developing countries, this may not be very applicable. There are other factors to consider which are also important in determining the suitability of the imported disinfection equipment and disinfectants.

A subjective process may be appropriate if the decision is simple. However, a subjective decision cannot be tolerated when a complex problem is encountered. A complex problem possesses many performance consequences which must first be ascertained and assessed with reasonable accuracy before a final decision can be reached. A point of interest is that the use of an explicit, logical, consistent, and replicable procedure does not exclude the user from employing subjective judgment. In the decision model suggested during this study, the assessment of the relative worth of an alternative is performed in a subjective manner. This internal judgment must be used in assigning measures of worth to various performance consequences among various criteria.

The method for evaluating the pilot disinfection systems in this study would be a decision-weighting model. This model assesses the effectiveness (in measures of worth) for each of the various system alternatives in relation to the preset requirements imposed.

In performing cost-effective analyses, the individual is confronted with two types of evaluations. The first is the cost analysis. Generally, this is a straightforward evaluation which consists of identifying all major system components and developing capital and operating cost estimates for these items. The second evaluation is the effectiveness evaluation in which a single measure or indicator of effectiveness is generated based upon multiple considerations. The objective of a complete cost-effective analysis is to compare monetary cost with effectiveness in order to identify the most cost-effective alternative. Assumptions and criteria for cost analysis should be carefully outlined. Retail or catalog list prices of equipment and supplies should be listed. Other specific cost parameters are: the equipment life, power cost and manpower expense for installation, operation, and maintenance, and so forth.

Prior to explaining the suggested method, it is important to clarify the concept of effectiveness or worth. In this case, effectiveness or worth of any object, activity, or situation refers to the extent to which the object is perceived by a decision maker or group of decision makers as satisfying a group or a range of clearly defined objectives. In other words, the effectiveness of an alternative within a specific job context would be defined in terms of how well that alternative satisfies the job's stated objectives. The above statements imply that the worth evolves from the decision maker's internal assessment. The effectiveness of an alternative, fulfilling an objective, is here conceived as inherent within the perceptual structure of the decision maker.

There are three psychological states which reflect the decision maker's choice and are fundamental to the concept of effectiveness. These are: (a) preference (positive-effective response), (b) aversion (negative response), and (c) indifference (possessing neither a preference for nor aversion to that object or activity). When dealing with the concept of effectiveness, positive preferences usually prevail. That is, when an object or activity is said to possess some measure of effectiveness, this usually means that someone possesses a positive preference for it or its consequences or both. The task here is to insure the assessment of all factors in such a manner that the true conceptual effectiveness of all alternatives is revealed. The procedure is summarized below. Figure 11 depicts the model outline; reference to this outline will aid in understanding the procedure.

ASSESSMENT PROCEDURE

The assessment procedure assumes that a decision maker has a series of alternative systems or devices (A_1, A_2, A_3, . . . A_n) which must be evaluated in terms of several measures of effectiveness or evaluating aspects (M_1, M_2, M_3, . . . M_n). The following rules must be followed when assessing the overall effectiveness of a set of alternatives (systems or devices):

1. The list of alternatives or systems should be complete.
2. All items listed should be mutually exclusive (i.e., no objective should encompass or be encompassed by any other objective listed).
3. The alternative list should contain only objectives in the highest order of significance.

Measures of Effectiveness (M)
and Relative Weights (w)

System Alternatives	M_1 (w_1)	M_2 (w_z)	M_j (w_j)	M_n (w_n)
A_1			.	
A_2			.	
.			.	
.			.	
.			.	
A_i	. . . . .	. . . .	r_{ij}	
.				
.				
.				
A_n				

Overall Effectiveness of Alternative i = $E(A_i) = \sum_{j=1} W_j r_{ij}$

Where: $\sum_{j=1}^{n} W_j = 1$

r_{ij} = Rating of Alternative i with respect to Measure j

Figure 11. System Effectiveness Analysis Model

4. Interdependence of effectiveness should prevail among the objectives listed.

Having observed these rules, the next step is to assign relative weights (w) to each of the "n" measures of effectiveness. It is important to emphasize that explicitness, logical consistency, and replicability do not preclude the use of judgment. However, an effort must be made to make the judgments in an objective manner rather than in a subjective one. The ultimate purpose of judgment is to compare relative importance among effectiveness criteria and to assess measures of effectiveness for various performance levels.

The weights assigned reflect the relative importance, in a preset arbitrary scale, of each measure of effectiveness. Generally, in deriving these relative weights, it is convenient to have each effectiveness-measure objective add up to one. By doing this, the resulting overall effectiveness ratings (computed as the sum of weighted individual-effectiveness ratings) may be subjected to the same interpretation as the effectiveness ratings or scores assigned to each individual-effectiveness measure.

Next, the decision maker assigns a score or rating which reflects the degree to which an alternative system or device satisfies each of the effectiveness measures (or requirements). In Figure 11, r_{ij} is the rating or score of alternative A_1 with respect to effectiveness measure M_j. The overall effectiveness can be calculated by summing the products of each rating and its relative weight as shown in Figure 11.

The use of the above decision model requires that the decision maker formulate the judgment at two critical steps. The first is in the assignment of weights depicting the relative importance of the effectiveness measures, and the second is in the assignment of ratings or scores for each alternative system or device to show how well it meets the criteria. These two steps cannot be avoided and as a consequence reflect the decision maker's opinion (as opposed to an absolute measure) on the relative importance of the effectiveness measures and how the alternatives measure up to the expectations. The accuracy of this model is a function of the validity of the specific judgments required to assign the effectiveness ratings or scores.

EFFECTIVENESS ANALYSIS

In accordance with discussions and a review of pertinent material during the first phase of the study, twenty-one measures of effectiveness were selected and ranked in order of decreasing importance (see Table 4). To facilitate an understanding of the effectiveness-analysis model, a description of these measures is given below:

M_1 - Satisfaction of Hydraulic Requirements Volume and pressure requirements are mandatory factors. These must be appropriate in order for the device to operate properly.

M_2 - Capital Cost of the Device In developing countries, money is a limited resource, especially in small communities for which these disinfection devices are designed. Therefore, cost consideration is of major importance.

M_3 - Cost of Disinfectant This measure of effectiveness is considered important because the disinfectant is not a one-time expense; it must be periodically resupplied. If its cost is high, it will discourage the user from continuing usage.

M_4 - Resupply to the Field Due to the remote location of these systems, resupply of spare parts and disinfectants to the field becomes important. Availability in the Philippines is also a key factor.

M_5 - Disinfection Power The power of the disinfectant can be directly connected to cost. Some disinfectants are more powerful than others, independent of the water quality. A high degree of bacteriological contamination and low disinfectant power can contribute to a high operational cost, operating difficulties, and high maintenance costs.

M_6 - Operation Reliability The system or device alternative must be capable of sustaining adverse handling, transportation, and operation conditions. Construction must also be durable enough to withstand adverse environmental conditions.

M_7 - Maintainability Maintenance must be compatible with the field environment. Major maintenance must not be frequently required. In developing countries, trained personnel are very scarce. System operation must not depend on a continuous supply of special materials. Modular components should facilitate ease of replacement and cannibalization.

M_8 - Dosing Accuracy The dosing mechanism should be simple and accurate. This would minimize calibration efforts, which if complicated, tend to discourage equipment use or may produce nonpalatable drinking water and, indirectly, a high maintenance cost. It should be possible to adjust in increments of not more that 0.2 ppm.

M_9 - User Acceptability The system or device must be acceptable to the consumers served. Difficulties may easily arise from actions which displease them or cause doubt or worry. In some instances, the presence of any taste or odor of disinfectant is sufficient cause for consumer rejection.

M_{10} - Installation or Modification Difficulties and Associated Costs Difficult installation or extensive modifications can involve a high capital cost and a demand for highly skilled personnel who may be available only infrequently in a developing country.

M_{11} - Safety (Degree of Safeness as a Result of Installation of Device) A device which is difficult to install in developing countries where trained and skilled personnel are not readily available may endanger the consumer if not properly installed. However, most likely, residents may not use the water source and return to using an undisinfected source.

M_{12} - Flow-Reduction Restrictions of Installing Device In some locations, the hydraulic pressure may already be quite low, and the installation of any installing device which produces a significant, additional reduction in flow would not be desirable.

M_{13} - Pressure-Loss Restrictions of Installing Device Some of the pilot devices require high-feed pressures due to the substantial pressure losses across the device. This could make their use infeasible in certain situations prevailing in developing countries.

M_{14} - Training Requirements for Operation Some of the devices may need operating personnel with a certain amount of training. Disinfection equipment requires calibration to obtain the required dosage of disinfectant in water. Calibration can only be accomplished by performing disinfectant residual analysis. To perform these analyses, personnel must be trained. Depending on the individual's level of education, this task may be simple or quite difficult.

M_{15} - Training Requirements for Maintenance The success of any system or device after installation is a function of the maintenance quality, and trained personnel are required. Some equipment requires more maintenance than others, and more training is necessary for the more complex devices.

M_{16} - Power Cost The electricity requirement is important since many locations in developing countries lack electrical power. The cost of this commodity is also a factor to be considered when calculating the operating cost. If not well maintained, electrical equipment can fail, creating many problems.

M_{17} - Field Storage Difficulties Depending on the location of the water system needing disinfection and the available storage facilities, this measure of effectiveness may or may not cause problems.

M_{18} - Durability Durability must be evaluated in terms of the susceptibility of the alternative systems or devices to weathering or cracking as a result of ultraviolet (UV) radiation in hot, humid climates. How this affects accuracy and life expectancy must also be assessed.

M_{19} - Susceptibility to Vandalism This measure of effectiveness evaluates the ease by which the system or device and/or parts can be stolen or damaged.

M_{20} - Shelf Life of Disinfectant Disinfectants intended for field use must be capable of remaining active for long periods of time before usage, especially when they must be transported to remote areas.

M_{21} - Space Requirement Sufficient space is important, especially when large quantities of disinfectant are required. However, it is not likely to be critical.

Table 4 lists the twenty-one measures of effectiveness that have been chosen and ranked. These, of course, in the final analysis may be rearranged after all the sites have been selected. However, at this time and from the experience gained up to now, this is a preliminary list.

In Column 2, "With Respect to the Next Item on the List", one can say, for example, that the shelf life is "x" number of times more important than the space requirement, and a susceptibility to vandalism is "y" number of times more important than the shelf life. The objective here is to subjectively judge the relative importance of each measure of effectiveness with respect to the one immediately below it. By a simple multiplication (see Appendix D), the importance of each item becomes relative to the last one on the list as shown in the third column, "With Respect to Last Item on the List". This, in turn, makes them relative to each other. By normalizing the third column, dividing each member by its total, (i.e., the sum of the individual values is 1), one can derive the relative weights (w) for each of the effectiveness measures. Column 4, "Normalized Relative Weights" shows these values. The validity of these values depends upon the decision maker's ability to provide accurate judgments in making the previous comparisions.

TABLE 4
EFFECTIVENESS CRITERIA AND RELATIVE WEIGHTS
FOR EVALUATING THE PILOT DISINFECTION DEVICES
AND DISINFECTANTS

Effectiveness Measures	Relative Importance With Respect to Next Item on the List*	Relative Importance With Respect to Last Item on the List	Normalized Relative Weights (NRW)
M_1 Satisfaction of Hydraulic Requirements			
M_2 Capital Cost of the Device			
M_3 Cost of Disinfectant			
M_4 Resupply to the Field			
M_5 Disinfection Power			
M_6 Operation Reliability			
M_7 Maintainability			
M_8 Dosing Accuracy			
M_9 User Acceptability			
M_{10} Installation or Modification Difficulties and Associated Costs			
M_{11} Safety			
M_{12} Flow-Reduction Restrictions of Installing Device			
M_{13} Pressure-Loss Restrictions of Installing Device			
M_{14} Training Requirements for Operation			
M_{15} Training Requirements for Maintenance			
M_{16} Power Cost			
M_{17} Field Storage Difficulties			
M_{18} Durability			
M_{19} Susceptibility to Vandalism			
M_{20} Shelf Life of Disinfectant			
M_{21} Space Requirement			

*This judgment value is the evaluation of one person; however, for the final evaluation, at least three persons will be involved.

TABLE 5
SUMMARY OF RATINGS, r_{ij}

Effectiveness Measures	Alternative to Next Devices*	Relative Effectiveness With Respect to Last Device	Relative Effectiveness With Respect to Pilot Disinfection Device	Ratings, r_{ij}
M_1 Satisfaction of Hydraulic Requirements	A_1			
	A_2			
	A_3			
	A_4			
	A_5			
M_2 Capital Cost of the Device	A_1			
	A_2			
.	A_3			
.	A_4			
.	A_5			
.	.			
.	.			
.	.			
.	.			
M_{21} Space Requirement	A_1			
	A_2			
	A_3			
	A_4			
	A_5			

*A_1 = WATER-SURE 050
A_2 = WATER-SURE 152
A_3 = Iodinator
A_4 = Total Water System
A_5 = Katadyn Water Filter, MF-7R

Having derived the relative weights for the effectiveness measures in a consistent and explicit manner, a similar procedure is employed to derive the respective rating scores (r_{ij}) for each alternative system or device. Assignment of ratings to the disinfectant devices or alternatives with respect to each of the effectiveness measures is conducted next. The reader should refer to Table 5 for a better understanding of the following discussion. Successive paired comparisons are made between adjacent alternatives on the list, starting at the bottom and working up. For example, how well does A_4 satisfy M_1 as compared to A_5?, and A_3 to A_4?, etc.). For each comparison, the decision maker makes a judgment about the relative degree to which each of the alternatives satisfies the effectiveness measure under consideration. This is similar to the procedure of assigning weights to the effectiveness measures (Table 4, "Effectiveness Criteria and Relative Weights for Evaluating the Pilot Disinfection Devices and Disinfectants"). The decision maker is required to indicate, in terms of a ratio, the degree to which one alternative (A_1) is superior to another (A_2) in terms of its effectiveness with respect to the measure (M_n) being considered. Since this decision-making procedure is primarily subjective, one must quantify the measurable criteria in order to make the assigned weights more objective. In Table 5, the values in Column 3, "With Respect to Next Device" are then multiplied, in the same manner as Table 4, to obtain the relative effectiveness of each alternative within each effectiveness-measure category (M_1,. . . M_n). The results are then shown in Column 4, "With Respect to Last Device". Column 4 numbers are then normalized by dividing them by their sum. The results are then shown in Column 5, "Ratings, r_{ij}". These are the respective ratings for the alternative systems with respect to the effectiveness measures. The reason for normalizing is to place all the derived ratings for the various effectiveness measures on the same basis (i.e., in the range of zero to one). However, any other range could be used similarly.

Once the respective weights for the twenty-one effectiveness measures and the respective ratings for each alternative device are obtained, the decision maker has all the data necessary to perform the calculations outlined in Figure 11. Appendix D shows a hypothetical example and detailed calculations for this type of model.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

Following two extensive inspection trips throughout the Philippines, it is clear that there are very few water supply situations where the equipment to be evaluated could be used. This is due primarily to a mismatch of the equipment characteristics with the requirements of the supply systems. Low-pressures are typical of the small systems viewed at locations of the Barangay Water Project and elsewhere. The only low-pressure device in the group to be evaluated was designed for intermittent operation, a circumstance that precluded its use in existing elevated tank systems even if the installation procedure had been completely practical.

The lack of a ready supply of disinfectant chemicals such as iodine and calcium hypochlorite tablets is a very severe handicap. There is no administrative infrastructure to accept the responsibility for obtaining supplies, particularly when orders are placed far in advance of supply need and shipment must take place from a foreign country to Manila and then to the location required. An importer's promise for delivery by a specified date should be regarded only as an optimistic estimate. The experience of USAID personnel indicates that extensive delays are the norm and may arise from problems in communication, transport, and/or passage through customs.

From these considerations, it is concluded that there are probably very few locations where any of the devices employing calcium hypochlorite or iodine could be installed, even under contrived conditions. There are fewer locations, perhaps none, where any of these devices would be the optimum choice, given an unlimited selection. Many very simple hypochlorinators have been devised and used in various parts of the world. Their low cost, ease of construction, and ease of operation make them very attractive for locations without electricity. For situations where electricity is available, the installation of a chemical-feed pump to inject calcium (or sodium) hypochlorite solution from a small tank into the water supply should be quite satisfactory.

The Walbro Total Water System with its instant disinfecting capability is very attractive, but in its present configuration and with its high-pressure requirements, it is not acceptable. It is also handicapped by the need for replenishment of a very special chemical available from only a single source in the United States.

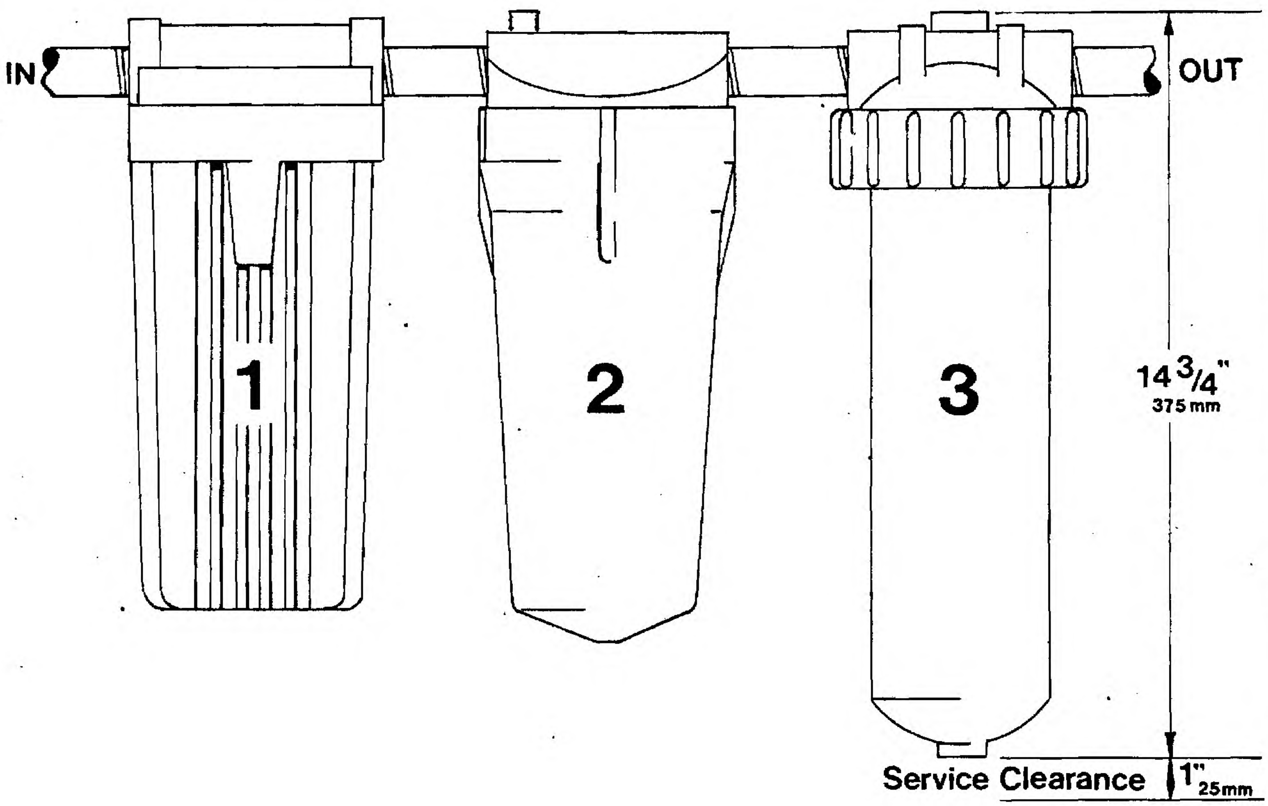
It is recommended that other countries be surveyed to determine if there are water supply systems that could reasonably utilize any of the various devices in question. If such systems can be found, the equipment already on hand in Manila should be installed and a program of continued monitoring should begin at once.

APPENDIX A

DISINFECTION EQUIPMENT - MANUFACTURERS LITERATURE

walbro TOTAL WATER SYSTEM

INSTALLATION



FILTER 1

THE WATERSTRAINER

This filter removes small particles such as dirt, rust or scale that may be in the incoming water supply.

The filter cartridge is available for either 10 or 25 micron filtration. The replaceable filters are of wovenfiber or paper construction.

FILTER 2

THE WATERFRESHNER

This filter removes chemicals commonly found in water supplys.

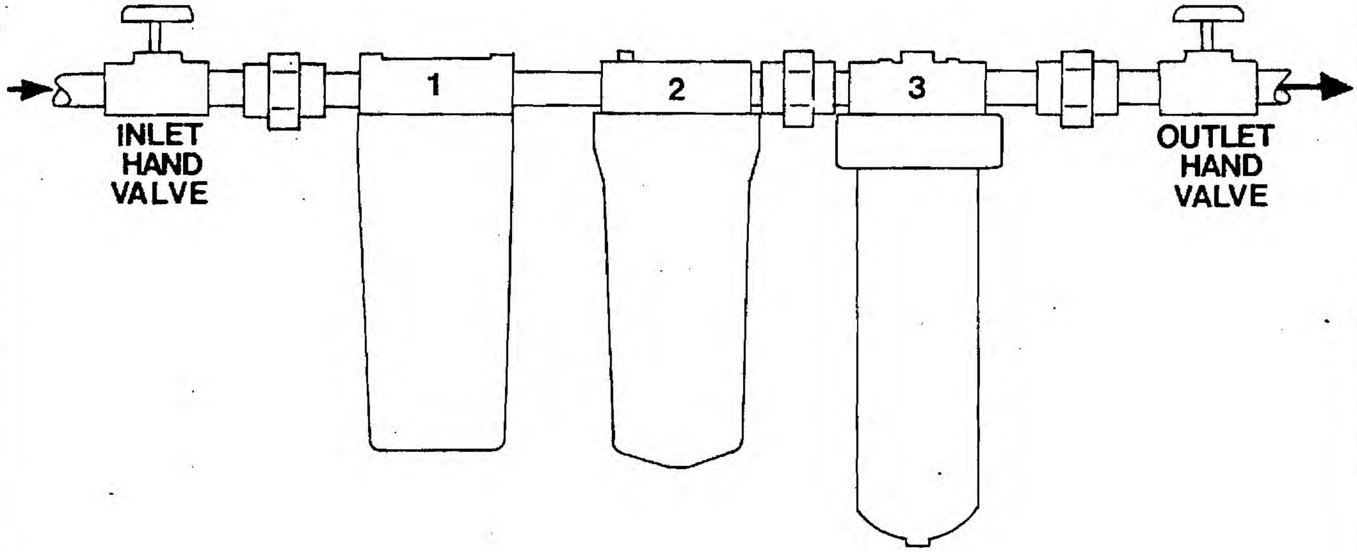
It also will remove bad taste and odors from the water. This replaceable filter contains activated carbon.

FILTER 3

THE PURIFIER

This filter contains TRI-OCIDE™ resin to purify the water and destroy all dangerous bacteria.

This final filter unit has been tested and sealed at the laboratory. The unit cannot be opened.



LIMITATIONS

The Walbro Total Water System is designed for working pressures up to 100 PSI (7 kg/cm) and a temperature limit of 120° F (50°C). Precaution should be taken to avoid applying this system above specifications.

LOCATION

Select a location that will allow the Total Water System to be installed vertically and be easily accessible to facilitate filter cartridge replacement.

PLUMBING

The plastic heads of the Total Water System filters are tapped for 3/4—inch U.S. Standard pipe thread. CARE SHOULD BE TAKEN NOT TO OVER TIGHTEN THE PIPING INTO THE PLASTIC HEAD. Use only teflon tape on threads coming in contact with the plastic.

An inlet shut—off valve must be used for servicing. An outlet shut—off valve may be used, if desired, to prevent drainage of water from piping during servicing.

When connecting the head assembly, be sure that the piping is aligned in such a manner that the regular piping is not supported by the head. A bracket, catalog number THB1 can be used.

FILTER CARTRIDGE REPLACEMENT

Cartridge replacement for FILTER 1 and FILTER 2 is accomplished by unscrewing the lower housing, after closing the inlet shut-off valve, removing the used cartridge and replacing it with the new one. Before replacing the housing, lubricate the threads and "O" ring on the plastic head with petroleum jelly or a similar lubricant. Replace the filter housing, tighten firmly, open the inlet valve and check for leaks at the filter housing.

FILTER 1

The waterstrainer woven fiber cartridge should be replaced when a noticeable pressure or flow rate drop occurs. The useful life of the Waterstrainer filter depends upon the amount of dirt, rust, etc. filtered out of the water, the micron size of the filter cartridge and the inlet line pressure.

FILTER 2

The waterfreshner activated carbon filter cartridge should be replaced when a noticeable pressure drop occurs or when objectionable taste or odor is detected. The useful life of the Waterfreshner cartridge depends on the amount of chemical contaminants removed from the water.

FILTER 3

The TRIOCIDE™ filter unit must be replaced when the TRIOCIDE™resin has become deactivated. The user schould calculate the water usage rate (80 gallons or 300 liters per person per day is U.S.A.average) and at a point approaching 100,000 gallons should test the water from the Total Water System each week (or more frequently) with the Total Water System Test Kit. Follow the instructions enclosed with the kit.

The TRIOCIDE™ filter unit is sealed at the laboratory and can be replaced only as a total unit. Close the inlet shut-off valve, loosen the couplings at each side of the plastic head, and remove the filter unit from the System. Remove the couplings and piping from the used filter and install into the plastic head of the new TRIOCIDE™ filter. Use treflon tape on the piping threads. Make sure, before replacing the new unit into the System, that the water flow will be in the correct direction. Place the filter into the Total Water System, tighten the coupling firmly, open the inlet valve and check for leaks.

Distributed by

walbro

7315 Wisconsin Ave., Bethesda, Maryland, U.S.A. 20014 • Telephone (301) 986-0550 • Cable WATERSURE WASHDC

World Water Resources Inc. Data Sheet

DRINKING WATER

INSTRUCTIONS

WATER-SURE 050

Your WATER-SURE 050 consists of 4 major parts which can be combined together to effectively chlorinate water issuing from a water system or other sporadic flow source. If you carefully follow these directions, step by step, you will obtain an effective, accurate means of disinfecting your water.

This instruction sheet has been written to cover standard installations and the most common installation forms.

PLEASE, READ IT FULLY BEFORE YOU START !!!!

If you have any questions regarding unusual installations, please contact your local WATER-SURE distributor or World Water Resources, directly.

I - Unpack the Unit

Check to see that all the package contents are present:

a. Inside siphon arm
b. Outside siphon arm
c. Rubber connector union
d. 050 base unit
e. Hopper with lid
f. Washers and spare parts
g. Chlorine test kit

II - Preparing the Ground

Before you begin the installation of your equipment, it is important to understand the placement of the WATER-SURE 050 in relationship to the water system. The WATER-SURE 050, when installed, consists of a holding tank and a chlorination device. This is placed between the water source and a chlorine contact tank. From the contact tank the treated water is safe.

III- Preparing the Holding Tank

A tank of at least 35 gallon capacity and no more than 175 gallon capacity must be placed next to your source to collect the water before disinfection by the WATER-SURE equipment. This tank can be purchased separately from your World Water Resources distributor. It will have all necessary fittings and pieces. You may, if you wish, use any other suitable tank. This tank should be mounted with its top at least 3" below the outlet of the source (see Diagram 1). This connection can be made with either plastic or cast-iron pipe connections. If you do not purchase a World Water Resources tank, please note that:

1) The outlet from the source should flow through a bag filter in the top of the retention tank. NOTE: For the unit to operate, no particle larger than 1/16" (80 mesh screen) can be in the water.

2) If the lid fits tightly on the tank, a breathing device must be installed. The tank must be at atmospheric pressure (this is generally not needed).

3) Before mounting the tank it must have a 1 5/8" hole drilled in the side, generally 20" up from the bottom of the tank (or 2/3 of the way from the bottom, whichever is less).

IV - Preparation of the 050

The 050 unit must be placed from 6" to 18" below the bottom of the holding tank. Adequate space must be made for this installation. Before placing the tank in position, connect the WATER-SURE 050 as follows:

a. Preparation of the inside siphon arm.

This is the shorter of the 2 arms found with the unit. Its plain end should be cut so that when the "L" end is connected to the hole on the side of the tank, the plain end is 3" to 5" above the inside bottom of the tank. This cutting can be done with any standard wood saw. A slight diagonal cut is desirable.

b. Determine the length of drop from the tank to the place where the WATER-SURE 050 is to sit. Don't forget to allow for the height of the WATER-SURE unit in making your calculation. The top of the WATER-SURE chlorination section must be at least 6" below the bottom of the holding tank.

c. Cut the plain end of the longer arm with a saw so that the WATER-SURE 050 when connected with the rubber union will be the desired length.

d. Now, place a washer over the threaded nipple extending from the "L" end and push this through the 1 5/8" hole in the side of the tank. Place a rubber washer over the nipple coming through the 1 5/8" hole. Attach the other arms to the nipple be rotating the outside arm to join it tightly to the holding tank. It must be rotated until a tight joint has been formed and both arms point straight down.

e. Attach the WATER-SURE 050 to the outside siphon arm by means of the rubber union and the two "O" clamps, making sure that the connections are tight.

V - Installing the Unit

a. Now place the tank with the siphon arms and unit in position. Make sure the tank has a firm foundation as it will become very heavy when filled with water, (one cubic foot of water weighs 64 lbs.). The WATER-SURE equipment can be fastened to its foundation through the holes that have been placed in the plate for your convenience.

b. Direct the water into the top of the WATER-SURE retention tank using standard plastic or metal fittings. An optional but recommended 1/16" strainer can be placed at this point or just pour the water in.

c. From the WATER-SURE 050 the water will enter a retention tank which can be supplied by World Water Resources for adequate chlorine contact time (30 minutes is recommended).

d. Be sure that all the connections are fully tightened and lined up straight.

VI - Closing Up

If you have followed these directions, the equipment is now ready for operation. Before you do any landscaping, make sure that you have easy access to the hopper, and preferably to the whole unit. As the chemicals are used, you must be able to add more to the system. The equipment requires no attention if properly installed, except for the addition of chemicals as required.

VII - Testing the WATER-SURE

To test the system, take the lid off the white hopper and fill it with calcium hypochlorite tablets marked HTH, which have been supplied with the unit. We suggest that you check out the unit by filling the holding tank with water to make certain that all of the connections are tight and so that you can see how the unit operates. As the water approaches the level of the upper elbow, you will notice that the equipment will discharge some water at the end of the WATER-SURE feeder. Within about 20 seconds after this has occurred, the siphon will take hold and the water will be discharged at the rate of about 20 gallons per minute.

Now repeat the filling experiment and about one-half way through the discharge run, take a sample of water and determine its chlorine content with the kit supplied with the apparatus. This is your reference point.

VIII- Increasing the Chlorine Dosage

Additional chlorine can be put into the water by twisting down the hopper further into the chlorinator in a clockwise directio

IX - Decreasing the Chlorine Dosage

Less chlorine can be put in the water by twisting the hopper out of the chlorinator, by rotating it in a counter-clockwise direction. When you have determined the settings for an increase and a decrease in chlorine content, you are ready to put the equipment into operation.

X - Determining the Chlorine Setting

Chlorine is consumed as it biologically purifies the water. If there is the proper amount of chlorine in the water after it has been allowed to stand for 30 minutes, it is safe. The chlorine test kit included with this equipment measures the amount of chlorin in the water. Generally, with this equipment, the chlorine residual should be between ½ and 1 ppm for safety. These actual tests must be run on the discharge water from the tank after passing through the unit. This test should be run several times during the first few days.

XI - Maintaining the Equipment

Keep the hopper at all times at least ¼ filled with hypochlorite tablets. In the initial stages, we recommend that the hopper be examined weekly to make sure that there are always hypochlorite tablets (HTH) present in the hopper.

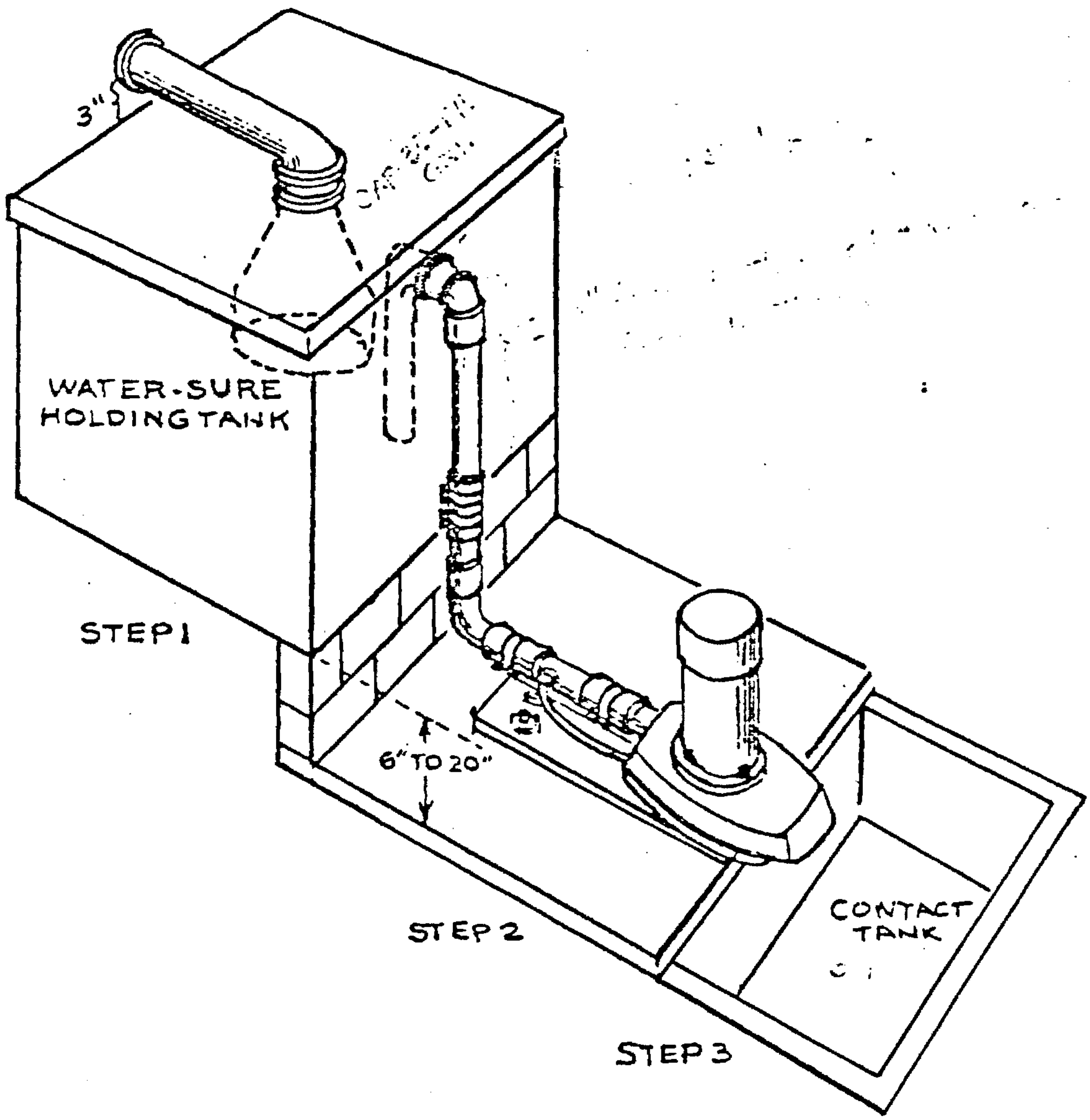
We recommend that at least once a month the hopper be removed from the feeder and cleaned of any white solid matter. This can be done with a stiff wire brush. We also recommend that the optional bag filter in the top of the tank be checked at the same time.

XII - References

If you have any questions, contact your local WATER-SURE representative or World Water Resources, Inc., 7315 Wisconsin Avenue, Bethesda, Maryland 20014.

For additional chemicals and chemical and biological test kits, see your local distributor or contact our Bethesda, Maryland office.

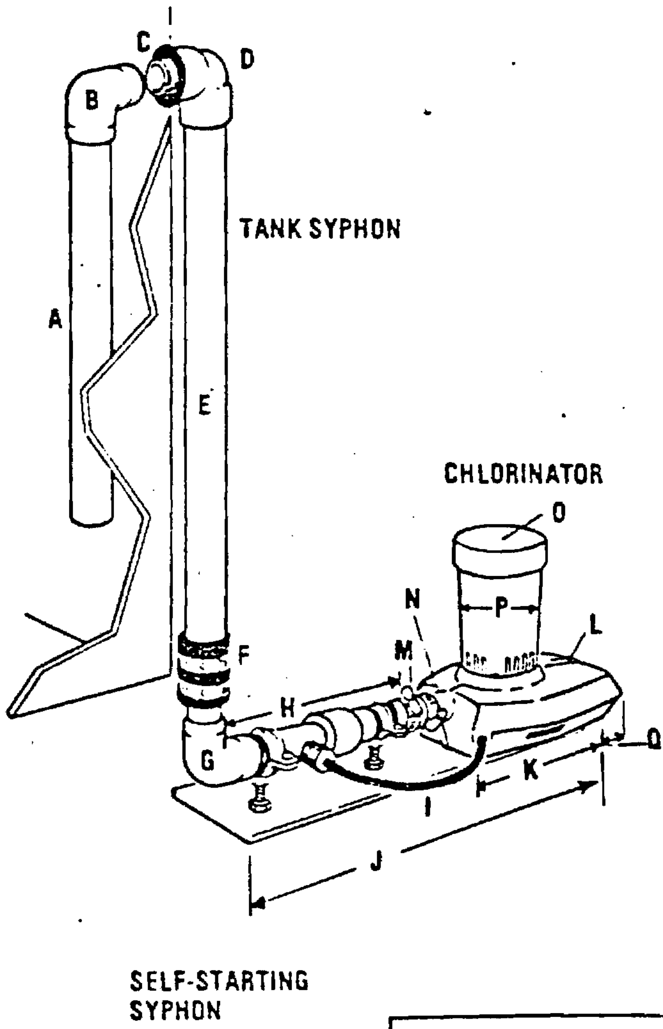
DIAGRAM 1
TYPICAL 050 INSTALLATION



7315 Wisconsin Ave., Bethesda, Maryland, U.S.A. 20014 • Telephone (301) 986-0550 • Cable: WATERSURE WASHDC

World Water Resources Inc.
Data Sheet

WATER-SURE® 050



TECHNICAL INFORMATION and OPERATIONAL CHARACTERISTICS

TANK
(Must be vented to Atmospheric pressure)

SURGE CAPACITY IN G/P/M = Tank Volume Above mid point in Syphon tap plus one minute flow rate

Particle size
passable through 80 mesh screen (1/16")

BASE UNIT
WEIGHT - 4 lbs.
OVERALL SIZES
LENGTH - 20"
WIDTH - 7"
HEIGHT - 13"

TANK SYPHON (1 ½ ID)
A - 26 in. (cuttable)
B - 3 in.
C - 1 in.
1 5/8" ID
D - 3 in.
E - 27 in. (cuttable)

SELF-STARTING SYPHON
F - 3½ in.
1 5/8" ID, 2" OD
G - 6 in.
H - 8 in.
I - 10 in.
J - 16 in.
4 ½ in. x ¼ in.

CHLORINATOR
K - 10 in.
L - 9 in.
M - 1¼ in.
N - 5 in.
O - 13 in.
P - 3 in.
Q - 4 1/8 in.

STARTING FLOW REQUIREMENTS
(½ gal./min. per ft.^{2}) or;

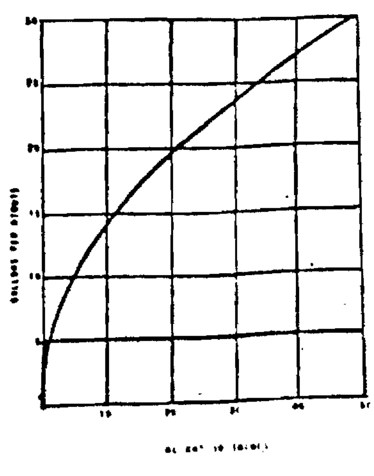
1ft^2 = ½	4ft^2 = 2	15ft^2 = 7½
2ft^2 = 1	5ft^2 = 2½	20ft^2 = 10
3ft^2 = 1½	10ft^2 = 5	25ft^2 = 12½

FLOW RATE

$$G = \sqrt{\frac{58.5\, HA^2}{1.12 + A^2}}$$

H = Height in in. from midway up the inside syphon arm (A) to bottom of the unit (G)

A = Area of pipe



7315 Wisconsin Ave Bethesda, Maryland, U.S.A. 20014 • Telephone (301) 986 0550 • Cable WATERAL WASHINGTON

World Water Resources Inc.
Data Sheet

INSTRUCTIONS

WATER-SURE 151

Your WATER-SURE 151 is comprised of 3 individual sections, combined together to yield a safe, effective means of chlorinating water in a pressure line. If you follow carefully these directions, step by step, for each of the sections, you will obtain an effective, accurate means of disinfecting your water system.

This instruction sheet has been written to cover standard installations and the most common installation forms.

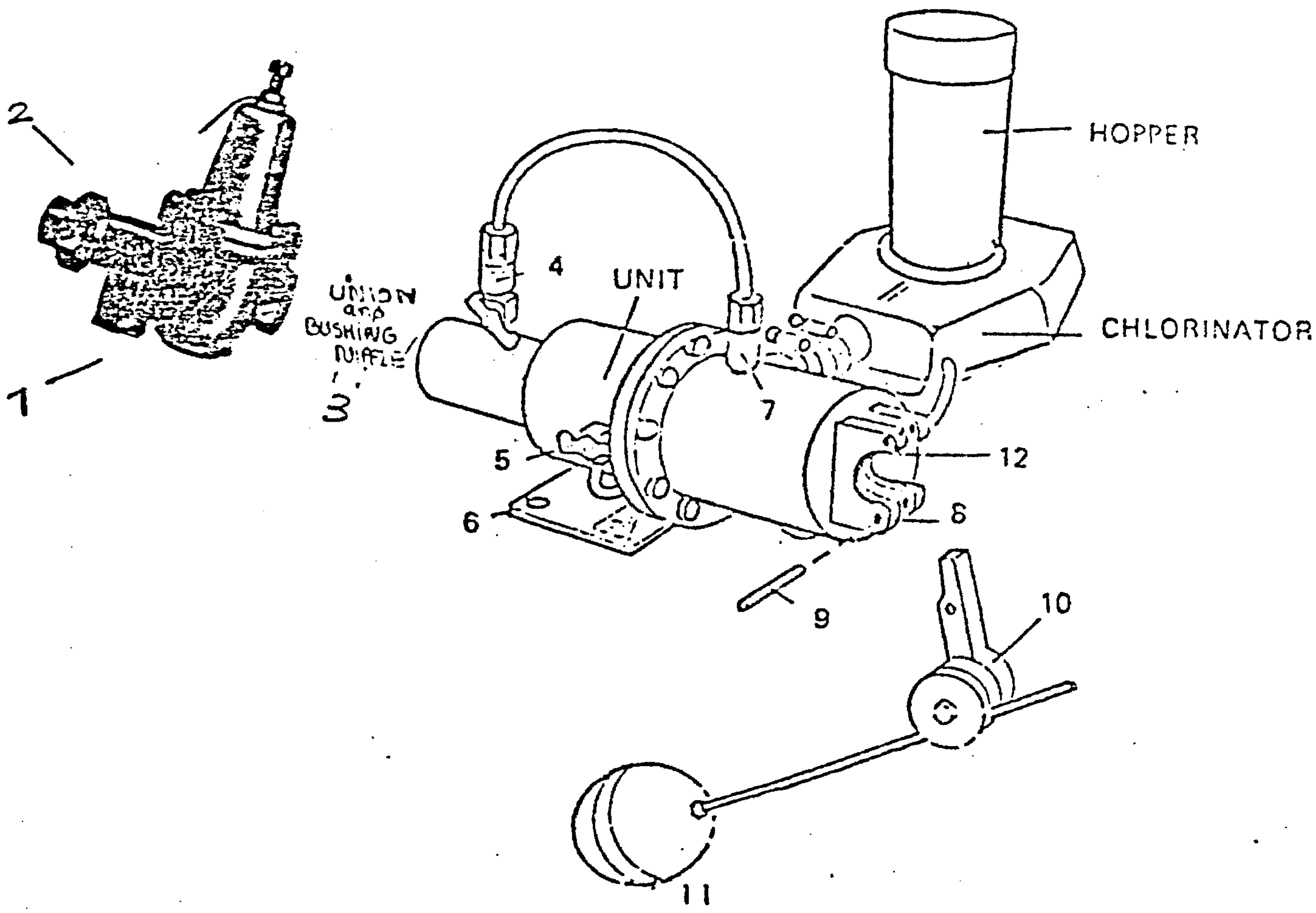
READ IT FULLY BEFORE YOU START!!!

If you have any questions regarding unusual installations, please contact your local World Water Resources WATER-SURE dealer or World Water Resources, directly.

I - Unpack the Unit

Check to see that all the package contents are present:

a. Pressure relief valve with gauge, union and bushing nipple.
b. WATER-SURE unit.
c. WATER-SURE hopper with lid.
d. Float control ball and arm.
e. Disinfection tank with lid and bulkhead fitting.
f. Venturi-jet pump with hose and fittings.
g. Chlorine test kit.



II - WATER-SURE Preparation

a) Assemble the WATER-SURE unit by connecting the PRV (1) to the back side of the WATER-SURE unit by means of fitting (3) which is connected to the PRV. Make sure that the union end of the PRV (2) points away from the unit. NOTE: It is recommended that your plumber install a 3/4" valve prior to the PRV union. The PRV requires a 3/4" line with pressures between (minimum 30 lbs. and maximum 100 lbs.).

b) Place the white hopper into the hole on top of the chlorinator. Screw the hopper until number (6) on the hopper is directly above the arrow lettered "D" on the wall of the chlorinator.

c) Check to be sure valve (4) is in the open position. Turn the valve completely to the left.

d) Check to make sure valve (5) is open by turning it completely to the left.

PPER

III - Disinfection Tank Preparation

a) A 20 gallon tank has been provided to store the disinfection solution made by the WATER-SURE unit. It is comprised of a tank, specially cut lid, and attached bulkhead exit port.

b) The WATER-SURE unit assembled above should be attached to the lid with the 2 screws provided. In proper position, section (10) of the float control arms should descend into the float arm hole of the lid.

c) Install the Float Control:

1) The ball (11) of the float control mechanism should be half full of water.

2) Remove pin (9) from hole (8) on the front of the unit.

3) Insert piece (10) between the lower holes of (8) on the front of the unit, and pin (9) should be installed through the holes.

4) Adjust the angle of ball (11) by tightening screw (10) to such a position that control (10) pushes the pin between (12) in, as the ball descends. The rod to which the ball is attached should be at maximum extension in the tank.

d) Attach the lid to the tank.

IV - The Injection System

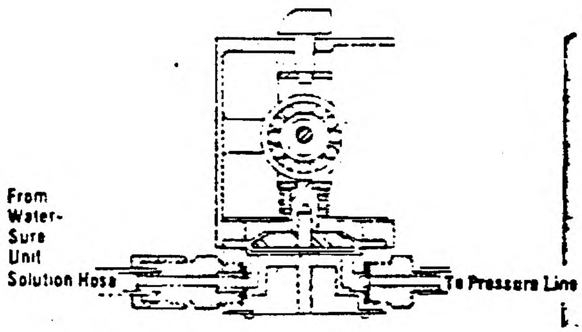
a) The injection system is the means of pulling the disinfection solution from the disinfectant tank to the water pressure line. This section has been completely prepared for installation.

b) The Unit should now resemble the enclosed picture.

V - Supplying Water to Make the Disinfectant

a) The WATER-SURE unit should now be connected to your pressurized water supply. This can be accomplished by the addition of a "T" into your pressure line and appropriate fittings to the WATER-SURE unit, at the pressure reducing valve.
NOTE: If the flow of water to the WATER-SURE unit is less than 12 1/2 gpm, a restriction must be put into the inlet side of

e) Chemical Feed Pump Application



VII - Starting the System

a) Add chlorine tablets to the hopper so that it is full.

b) Open all valves to the WATER-SURE thereby allowing water to run through the unit into the disinfection tank. Allow the disinfection tank to fill 3/4 full.

c) Adjust fitting (10) and ball (11) up and down and at various angles so that the pin between (12) is fully extended when the tank is 3/4 to 4/5 full. As the amount of solution in the tank decreases, the unit will automatically turn on and refill the tank. TAKE YOUR TIME AND MAKE SURE THE ADJUSTMENT IS CORRECT. THIS IS IMPORTANT.

VIII - Controlling the Chlorine

a) Chlorine is consumed in biologically purifying the water. If there is chlorine in the water after sufficient time has elapsed, the water is safe to drink. The amount of chlorine in the water is measured by the enclosed chlorine test kit (See instructions enclosed in kit). In general, the chlorine residual should be kept at .5ppm at the furtherest point on your line.

b) Increased chlorine dosage may be obtained in the pressure line in 3 ways:

1) By lowering the hopper further into the chlorinator i.e. by screwing the hopper down.

VII - Testing the WATER-SURE

To test the system, take the lid off the white hopper and fill it with calcium hypochlorite tablets marked HTH, which have been supplied with the unit. We suggest that you check out the unit by filling the holding tank with water to make certain that all of the connections are tight and so that you can see how the unit operates. As the water approaches the level of the upper elbow, you will notice that the equipment will discharge some water at the end of the WATER-SURE feeder. Within about 20 seconds after this has occurred, the siphon will take hold and the water will be discharged at the rate of about 20 gallons per minute.

Now repeat the filling experiment and about one-half way through the discharge run, take a sample of water and determine its chlorine content with the kit supplied with the apparatus. This is your reference point.

VIII- Increasing the Chlorine Dosage

Additional chlorine can be put into the water by twisting down the hopper further into the chlorinator in a clockwise direction.

IX - Decreasing the Chlorine Dosage

Less chlorine can be put in the water by twisting the hopper out of the chlorinator, by rotating it in a counter-clockwise direction. When you have determined the settings for an increase and a decrease in chlorine content, you are ready to put the equipment into operation.

X - Determining the Chlorine Setting

Chlorine is consumed as it biologically purifies the water. If there is the proper amount of chlorine in the water after it has been allowed to stand for 30 minutes, it is safe. The chlorine test kit included with this equipment measures the amount of chlorine in the water. Generally, with this equipment, the chlorine residual should be between ½ and 1 ppm for safety. These actual tests must be run on the discharge water from the tank <u>after</u> passing through the unit. This test should be run several times during the first few days.

XI - Maintaining the Equipment

<u>Keep the hopper at all times at least ¼ filled with hypochlorite tablets</u>. In the initial stages, we recommend that the hopper be examined weekly to make sure that there are always hypochlorite tablets (HTH) present in the hopper.

2) By further opening valve (5) on the unit.

Both 1 and 2 increase the strength of the solution being injected into the pressure line.

3) If the optional venturi was used, by adjusting the lock nut and the connector on the venturi. This is a valve. The further out you adjust the lock nut the more solution is added.

c) Decreased chlorine dosage may be obtained:

1) By screwing the hopper up.

2) By closing valve (5) if it has been opened.

3) If the optional venturi was used, by adjusting the lock nut and connector on the venturi.

Note: Once the chlorine tablets have been dampened by too deep an insertion, it will take up to 2 hours for these pills to dry out enough to give accurate readings. Start with too little chlorine and increase the dosage.

IX - Maintaining the Equipment

a) Keep the hopper filled with chlorine tablets.

b) Occasionally, the small weep hole in the center bottom of the exit port of the WATER-SURE should be cleaned and checked by running a small wire through the hole. This process can be done from inside through the hopper hole.

c) On particularly hard water, calcium deposit may develop in the base of the disinfection tank. This tank should be washed with clean water on occasion.

d) If the optional venturi-jet pump was used it will need an occasional inspection.

e) The chlorine residual in the water should be checked each day for the first 10 days and each time the hopper is filled thereafter. If there are no chlorine tablets in the hopper, you are not chlorinating the water.

IF YOU HAVE ANY QUESTIONS OR ANY DIFFICULTIES, PLEASE CONTACT YOUR LOCAL WATER-SURE DISTRIBUTOR WHO WILL BE PLEASED TO HELP YOU.

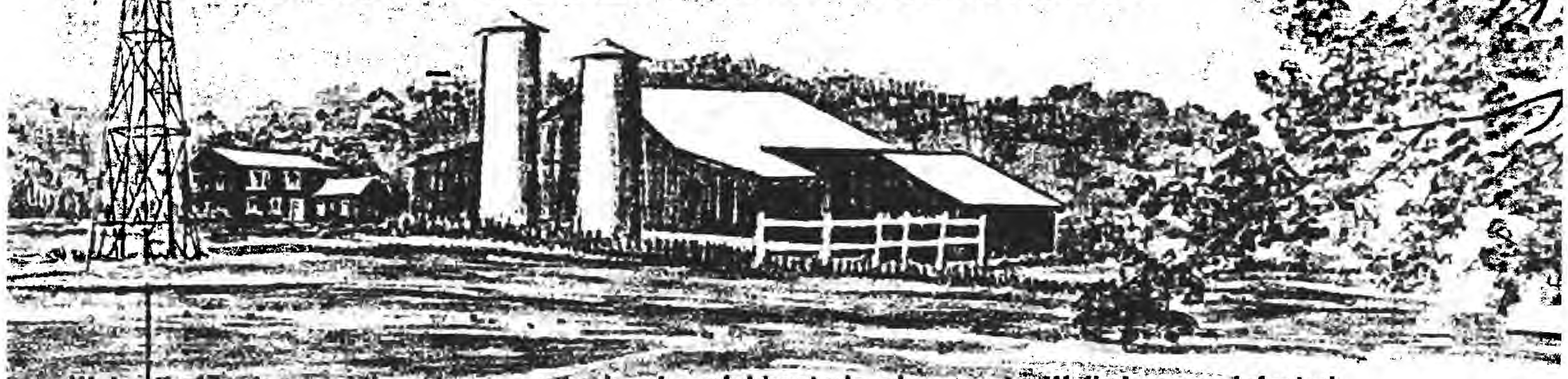
IODINAMICS Disinfection Systems

T.M.

- Guards against harmful bacteria, viruses, fungi, and cysts in water.
- Simple to install: no electricity required.
- No moving parts, no breakdowns.
- Contains iodine, an effective disinfectant.
- No objectionable odor or taste.

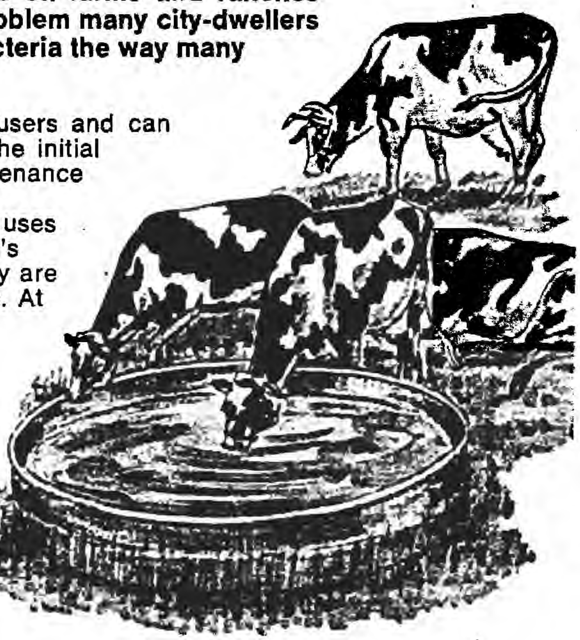
IODINATORS

AN EFFECTIVE WAY TO MAKE SURE THE WATER YOU DRINK IS SAFE FROM CONTAMINATION



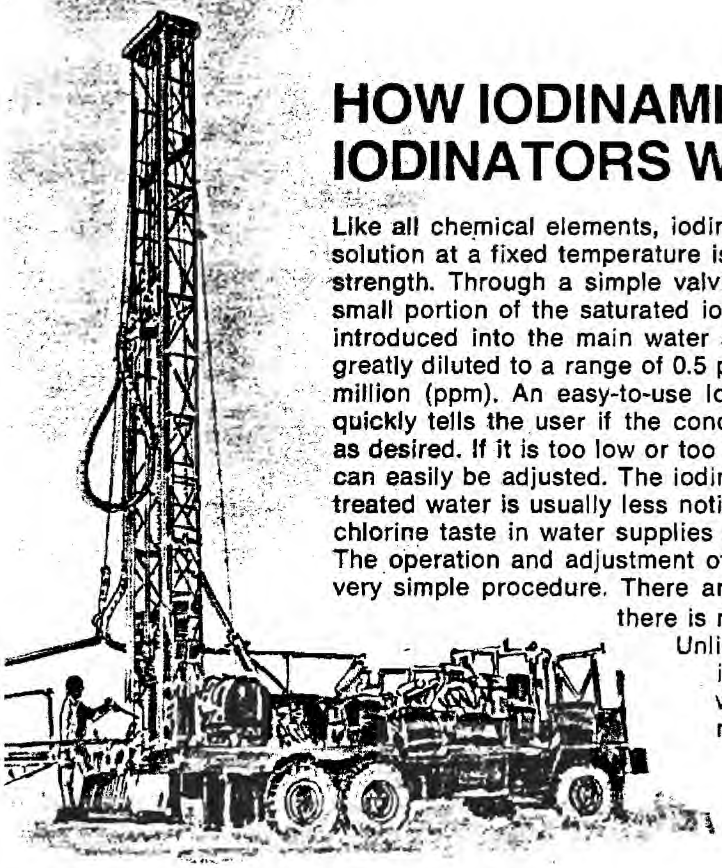
Water that looks sparkling clean may harbor harmful bacteria, viruses, etc. Wells become infected through ground seepage, from corrals and septic tanks. Sometimes whole water tables are contaminated. Germs grow within holding tanks and in the piping that carries water to homes and livestock.

Any water supply can become contaminated. But people who live on farms and ranches and drink water from their own wells often face a contamination problem many city-dwellers don't have. Rural water supplies are almost never protected from bacteria the way many city water supplies are.



Chlorination systems used in urban areas are designed for large-volume users and can be expensive and bulky. Few individual farms and ranches want to make the initial investment in chlorination machinery and undertake the complicated maintenance required to make sure it operates dependably.

Now there is a safe, positive way to control bacteria in water supplies. It uses one of mankind's most reliable germicides—**iodine.** Iodinamics Corporation's disinfection systems are trouble-free, inexpensive, and easy to install. They are designed to be used by individual consumers and on private water sources. At present, **Iodinator®** Systems are on the job protecting water supplies for thousands of users throughout the United States. And many more are at work overseas.



HOW IODINAMICS IODINATORS WORK

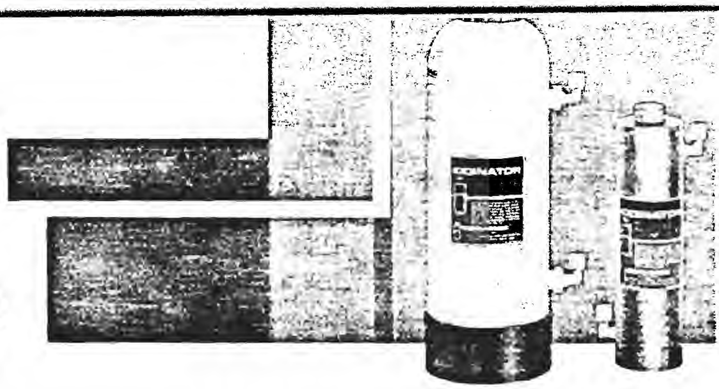
Like all chemical elements, iodine in a saturated solution at a fixed temperature is always of consistent strength. Through a simple valving system, a very small portion of the saturated iodine solution is introduced into the main water stream where it is greatly diluted to a range of 0.5 part to 1.0 part per million (ppm). An easy-to-use Iodinamics test kit quickly tells the user if the concentration of iodine is as desired. If it is too low or too high, the feed supply can easily be adjusted. The iodine taste, if any, in treated water is usually less noticeable than the chlorine taste in water supplies so treated.

The operation and adjustment of the Iodinator is a very simple procedure. There are no moving parts; there is no need for electricity. Unlike chlorinators, there is no need for venting, wiring, or complicated maintenance.

IODINATORS OFFER GOOD PROTECTION

Because iodine is more stable chemically than chlorine and other germicides, and less affected by sunlight, pH and temperature, iodine gives more consistent and more lasting protection against microorganisms. Other germicides tend to combine with organic materials and lose their potency. Iodine is less volatile, safer to work with and even less noticeable to the taste than chlorine—yet iodine effectively protects against microorganisms commonly found in most water supplies.

QUESTIONS AND ANSWERS ABOUT IODINATOR® SYSTEMS



Q. How do I know when to add iodine crystals to my Iodinator?

A. Your Iodinator will perform at its best if the level of iodine crystals never drops below one-third full. A periodic visual check will let you know how low the crystals are. It does no harm, however, to refill the Iodinator before it has reached the two-thirds empty mark, so you might routinely add crystals at this time, usually every six months or so.

Q. Does water treated with iodine have an objectionable odor or taste?

A. At the recommended treatment level (0.5 to 1.0 ppm), there usually is no noticeable odor or taste. At a residual approaching 2.0 ppm, some people may detect a slight taste. If such a taste is objectionable, a carbon filter can be installed as near the point of use as possible.

Q. Will a water supply containing iron have any adverse effect on the function of the Iodinator Disinfection System?

A. Iron is most commonly found in water in either the dissolved or precipitated form. Dissolved iron has no effect on the function or effectiveness of the Iodinator nor will iodine precipitate the dissolved iron. If the level of precipitated iron is high enough to be visible, prefiltration is recommended to prevent Iodinator pluggage. It should be noted that dissolved iron, when allowed to sit idle and become exposed to air, will precipitate (become visible) whether or not iodine is present in the water.

Q. Will iodine kill iron bacteria?

A. Yes, but in most cases special steps must be taken to assure complete effectiveness. If iron bacteria is a problem for you, consult your Iodinator dealer or distributor.

Q. Will the use of an Iodinator have an adverse effect on the normal operation of a septic tank system?

A. No. At the point where iodinated water enters a septic tank the bacterial demand is so great that the trace amount of iodine remaining is quickly rendered ineffective as a germicide; there are no harmful effects on the septic system.

Q. Can an Iodinator be used to solve a hydrogen sulfide problem in water?

A. It takes approximately 7.4 ppm of iodine residual to offset each part per million of hydrogen sulfide. Iodinators have been used successfully to treat hydrogen sulfide in water when the hydrogen sulfide content is low (0.1-0.5 ppm). Whenever an Iodinator is being considered to disinfect water containing hydrogen sulfide levels above 0.5 ppm, our Technical Department should be consulted through your dealer or distributor before installation.

Q. Is it ever necessary to prefilter water before iodination?

A. Yes. Water high in particulate matter, such as pond or lake water, should be filtered to eliminate pluggage of the Iodinator.

Q. Has there been any evidence that drinking iodinated water has caused health problems?

A. There are thousands of Iodinator Disinfection Systems installed on private and public water systems throughout the United States. Many of these have been in service for several years. So far as our records show, no claims have been made to us to the effect that drinking iodinated water has caused any adverse health conditions. Iodinated water has been consumed by selected inmates of two Florida prisons since 1964.* Periodic testing on their blood serum and a careful monitoring of their general health has indicated no illnesses or health problems relating to their consumption of iodinated water. We do recommend, however, that people who are on special diets or under a physician's care, consult their doctor before drinking iodinated water. At the present time, Iodinator systems are being used to disinfect waters at restaurants, rest areas, and other semi-public places in states now approving such use. Our Iodinator Disinfection Systems are at work in national parks, forests and camp areas. Continuing research is suggesting that iodine is a suitable disinfectant for almost any water system.

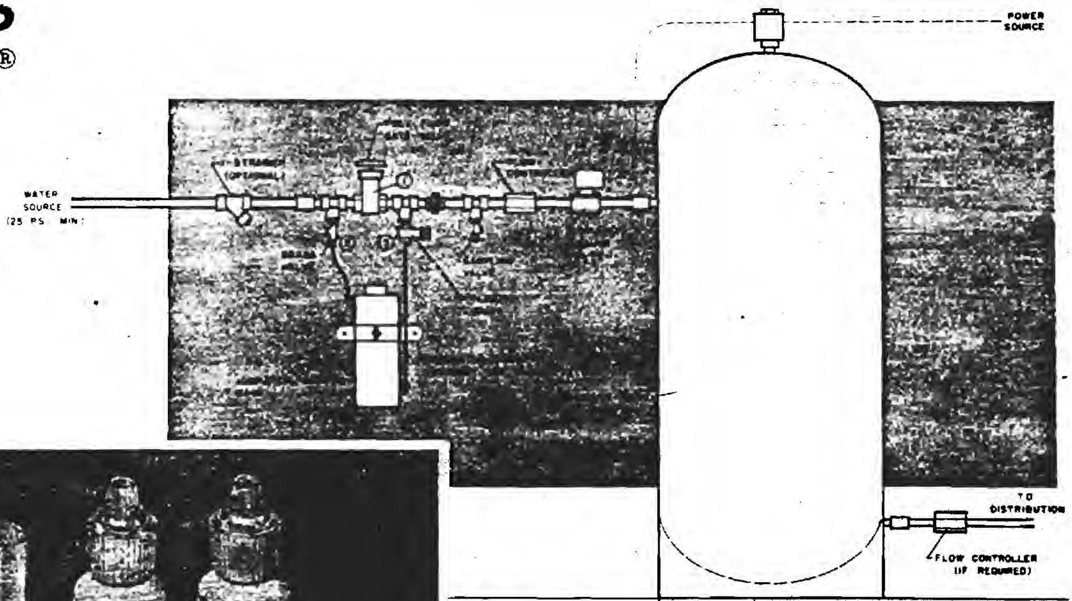
Q. Are there other applications for Iodinators besides safeguarding water supplies?

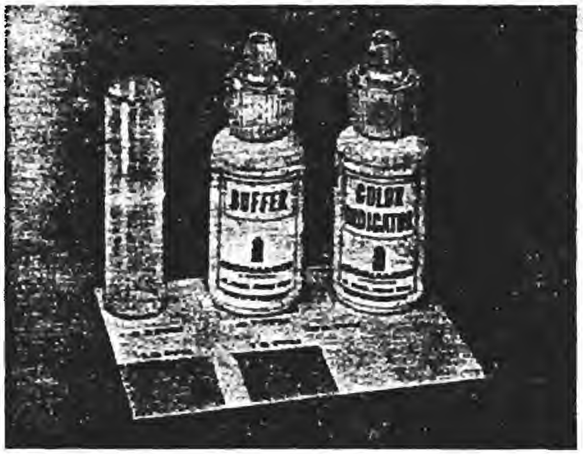
A. Yes. A simple adjustment makes it possible to increase the residual content of the iodine in water. The dairy industry—and other industries concerned with the sanitation of foodstuffs—use this more concentrated solution to clean equipment, stalls, and as an udder wash. If you are contemplating such uses, contact your dealer or distributor for complete information.

*Equipment Development and Test Report 7400-1, U. S. Department of Agriculture, Forest Service, San Dimas, CA, Jan. 1976.

IODINAMICS IODINATOR® SYSTEMS

Surge Tank System for use on variable flow water systems





Iodinamics Residual Iodine Test Kit gives accurate, fast indication of iodine content in water. Simply rinse the tube with sample water, fill it, add two drops of buffer solution and shake, then add a drop of color indicator. The resulting color is then matched to the color chart to determine residual within .2 parts per million.

INSTALLATION/OPERATING INSTRUCTIONS OF A TYPICAL RESIDENTIAL SYSTEM

1. Install the Iodinamics Iodinator between pump and a holding tank, (pressure tank, storage tank) as near to the pump as possible. If no holding tank exists, it is necessary to install a tank to permit the Iodinator to work efficiently. To determine tank capacity, multiply gpm (gallons per minute) pump rating by 9. Example: 6 gpm pump rating times 9=54 gallon holding tank necessary.

2. Remove plug from top of the Iodinator tank. After reading the label on the container, slowly and carefully pour in the supplied Iodinamics Iodine Crystals. **CAUTION:** Iodine may stain fabric or stain and irritate skin. To avoid this, rubber gloves should be worn and care taken in handling the material.

3. Completely open valves 1, 2, and 3.

4. Establish the pressure differential necessary by closing full port valve No. 1 one-quarter to one-half turn from the completely open position.

5. Upon initial installation, allow one-half hour for iodine to go into saturated solution prior to making first residual test. Make first tests from drain valve No. 4, located as close to holding tank as possible.

6. Determine residual iodine (0.5 ppm-1.0 ppm) according to the instructions in the Iodinamics Residual Iodine Test Kit provided.
NOTE: When a carbon filter is used there will be no residual iodine in water samples obtained after the carbon filter.

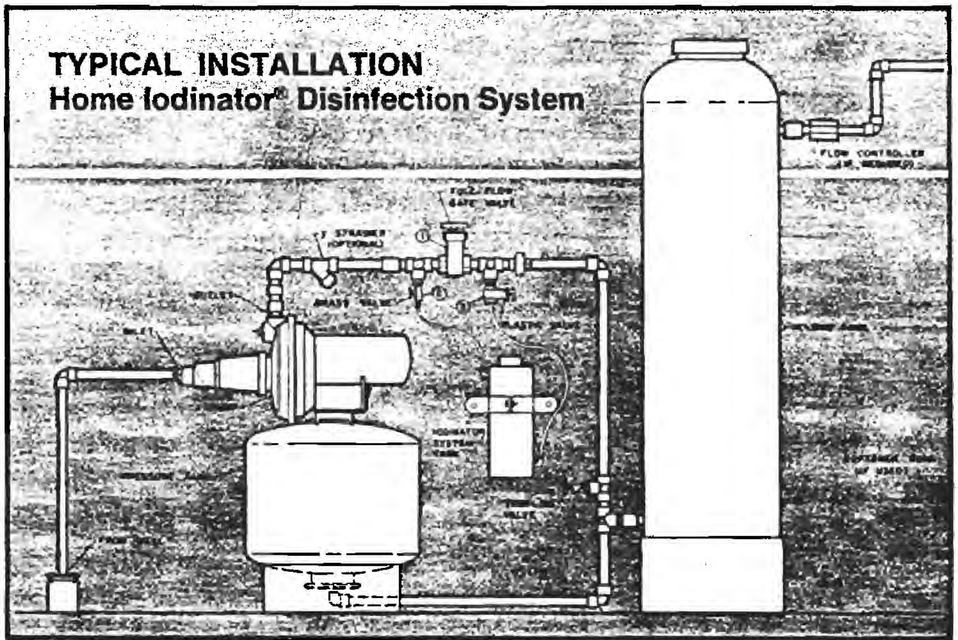
7. Adjustments: Too much iodine (more than 1.0 ppm): Open valve No. 1 until desired residual is obtained. Too little iodine (less than 0.5 ppm): Close valve No. 1 until desired residual is obtained. Make a test the day after installation from the most remote tap in the system. Adjust valve No. 1 as necessary.

NOTE: In certain installations, an existing pressure differential may be encountered due to elbows in the line, etc. If so, there is the possibility that, even with valve No. 1 completely open, greater than necessary residual iodine will be found. This same occurrence is possible when the service or main line is below the Iodinator, creating a siphon action. These situations are easily controlled by making a loop in tubing to at least the height of the tank. Should additional control be necessary, use the valve on the "iodine" line, valve No. 3.

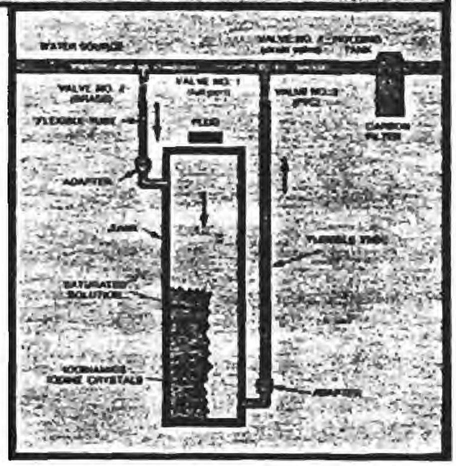
8. Check iodine crystal level in Iodinator tank at least every six months. To do this, completely close valves No. 2 and 3. Open plug slightly to relieve pressure, then remove plug from tank and measure depth of iodine crystal bed with a ruler or clean rod. Should iodine bed be 2/3 depleted, replenish with a new supply of Iodinamics Iodine Crystals.

IODINATORS ARE EASY TO INSTALL AND MAINTAIN

Connect your Iodinator directly into your water system between the pump and storage tank. Its simple design, compact size, and sturdy construction make installation fast and easy.
The low concentration of iodine residual must be retained in a holding tank for a few minutes before use, so the germicidal effect can take place. In most cases, your present storage tank will do the job well. The smallest Iodinator can treat approximately 160,000 gallons of water (at 0.5 ppm residual feed) before it needs refilling. Iodinators are available in several sizes to fill virtually any disinfection requirements. When it is time to refill the Iodinator, simply unscrew the cap and pour in new iodine crystals. It takes only a few moments.



Drawing of Iodinator shows how water moving through the system becomes saturated with iodine and is then mixed in precise quantities with the main water stream to control germs.



IODINATORS ARE EFFECTIVE

Iodinamics Iodinators can control the following organisms in the approximate contact time indicated. This is only a partial list — the Iodinator controls many other kinds of organisms, too.

APPROXIMATE CONTACT TIME IN WHICH THESE POTENTIALLY DANGEROUS ORGANISMS CAN BE CONTROLLED WITH AN IODINAMICS IODINATOR®

(0.5 ppm iodine, pH 7.5, 20°-26° C.)

BACTERIA	DISEASE CAUSED	APPROXIMATE CONTACT TIME
Escherichia coli	Cystitis of urinary tract	50 seconds*
Salmonella typhosa P-4	Typhoid fever; gastro-enteritis	1 minute**
Salmonella typhosa P-5	Typhoid fever; gastro-enteritis	1 minute**
Salmonella typhosa P-10	Typhoid fever; gastro-enteritis	1 minute**
Salmonella paratyphi P-2	Paratyphoid fever	1 minute**
Salmonella schottmuelleri P-3	Paratyphoid fever	2 minutes**
Salmonella typhimurium P-6	Food poisoning	5 minutes**
Shigella flexneri P-7	Paradysentery	2 minutes**
Shigella dysentariae 11 P-8	Dysentery; intestinal ulcers	2 minutes**
Shigella sonnei P-9	Paradysentery	2 minutes**
Streptococcus fecalis E-40	Can be pathogenic	2 minutes**
Staphylococcus aureus	Septicemia; brain abscess; enteritis	50 seconds†
Staphylococcus epidermidis	Subacute endorcarditis	1 minute†
VIRUS		
Poliovirus Type 1	Polio	9 minutes*
CYSTS (@ 1 ppm iodine)		
Entamoeba histolytica	Severe dysentery	30 minutes*

Contact times to control the above bacteria, viruses and cysts have been obtained through the research of the following persons and their reports upon which we are relying. The listing of these times can be found in the cited publications.

*Black et al, "Iodine for the Disinfection of Water", Journal AWWA, Vol. 60, No. 1, January 1968.

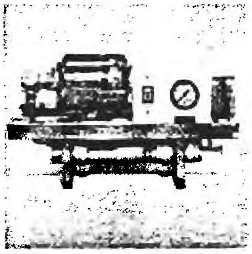
**Chambers, C. W. et al, Bacteriology Section, Environmental Health Center, U. S. Public Health Service, Cincinnati, Ohio.

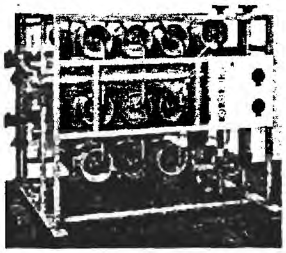
†Keirn, M. A. and Putnam, H. D., Ph.D., *Health Laboratory Science*, Vol. 5, July 1968.

CONTINENTAL® SOLVES YOUR WATER PROBLEMS MANY WAYS.

REVERSE OSMOSIS

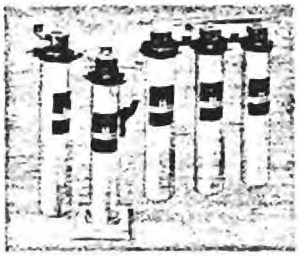
Iodinamics Corporation's parent company also produces RO systems ranging in size from the one at the right, which produces as little as 200 gpd, to large systems, at far right, that produce 100,000 gpd and can be connected in parallel series for unlimited quantities of solids reduced-water.

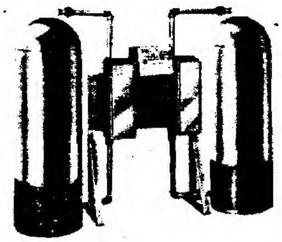




DEIONIZATION

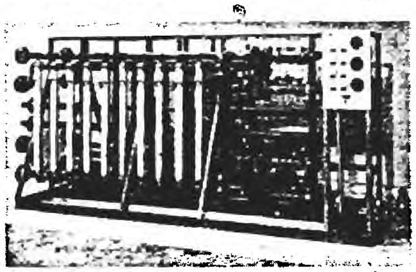
CONTINENTAL deionizers can produce the ultimate in achievable water purity — 18 megohm specific resistance water. From left to right, are cartridge DI systems, service exchange deionizers, and automatic deionizers that regenerate their ion-exchange beds automatically.

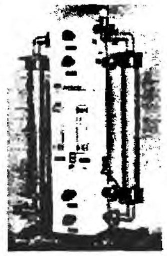




ULTRAFILTRATION

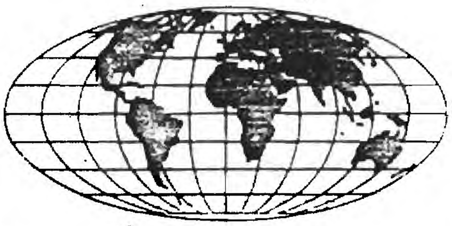
CONTINENTAL ultrafiltration systems use a membrane barrier to filter undissolved, suspended or emulsified solids as small as .01 micrometers (microns) from water. Both systems shown at right are easily expandable when necessary.





IODINAMICS T.M.
CORPORATION
A Subsidiary of Continental Water Conditioning Corporation

Call or Write —



Continental® Service

CONTINENTAL water treatment systems are serviced by knowledgeable, highly-trained experts located near you.

BILL REYNOLDS
CONTINENTAL WATER
CONDITIONING CO.
P. O. BOX 29483
ATLANTA, GA. 30359
404-455-0481

P. O. Box 20018, El Paso, Texas 79998 • Phone: 915/852-9090 • Telex: 74-9491 • Cable Address: CONTINENTAL ELP.
 Cat. No. 9107-X (877)—PRINTED IN U.S.A.

INSTALLATION/OPERATING INSTRUCTIONS

1. Install the Iodinamics Iodinator® between pump and a holding tank, (pressure tank, storage tank) as near to the pump as possible. If no holding tank exists, it is necessary to install a tank to permit the Iodinator® to work efficiently. To determine tank capacity, multiply gpm (gallons per minute) pump rating by 9. Example: 6 gpm pump rating times 9 54 gallon holding tank necessary.

2. Remove plug from top of the Iodinator® tank. After reading the label on the container, slowly and carefully pour in the supplied Iodinamics Iodine Crystals. Caution: Iodine may stain fabric or stain and irritate skin. To avoid this, rubber gloves should be worn and care taken in handling the material.

3. Completely open valves 1, 2, and 3.

4. Establish the pressure differential necessary by closing full port valve No. 1 approximately one quarter to one-half turn from the completely open position.

5. Upon initial installation, allow one-half hour for iodine to go into saturated solution prior to making first residual test. Make first tests from drain valve No. 4, located as close to holding tank as possible.

6. Determine residual iodine (0.5 ppm. — 1.0 ppm) according to the instructions in the Iodinamics Residual Iodine Test Kit provided. Note: There will be no residual iodine in water samples obtained after the carbon filter.

7. Adjustments. Too much iodine (more than 1.0 ppm): Open valve No. 1 until desired residual is obtained. Too little iodine (less than 0.5 ppm): Close valve No. 1 until desired residual is obtained. Make a test the day after installation from the most remote tap in the system. Adjust valve No. 1 as necessary.

   NOTE: In certain installations, an existing differential may be encountered, due to elbows in the line, etc. If so, there is the possibility that, even with valve No. 1 completely open, greater that necessary residual iodine will be found. This same occurrence is possible when the service or main line is below the Iodinator®, creating a siphon action. These situations are easily controlled by making a loop in tubing to at least the height of the tank. Should additional control be necessary, use the valve on the "Iodine" line, valve No. 3.

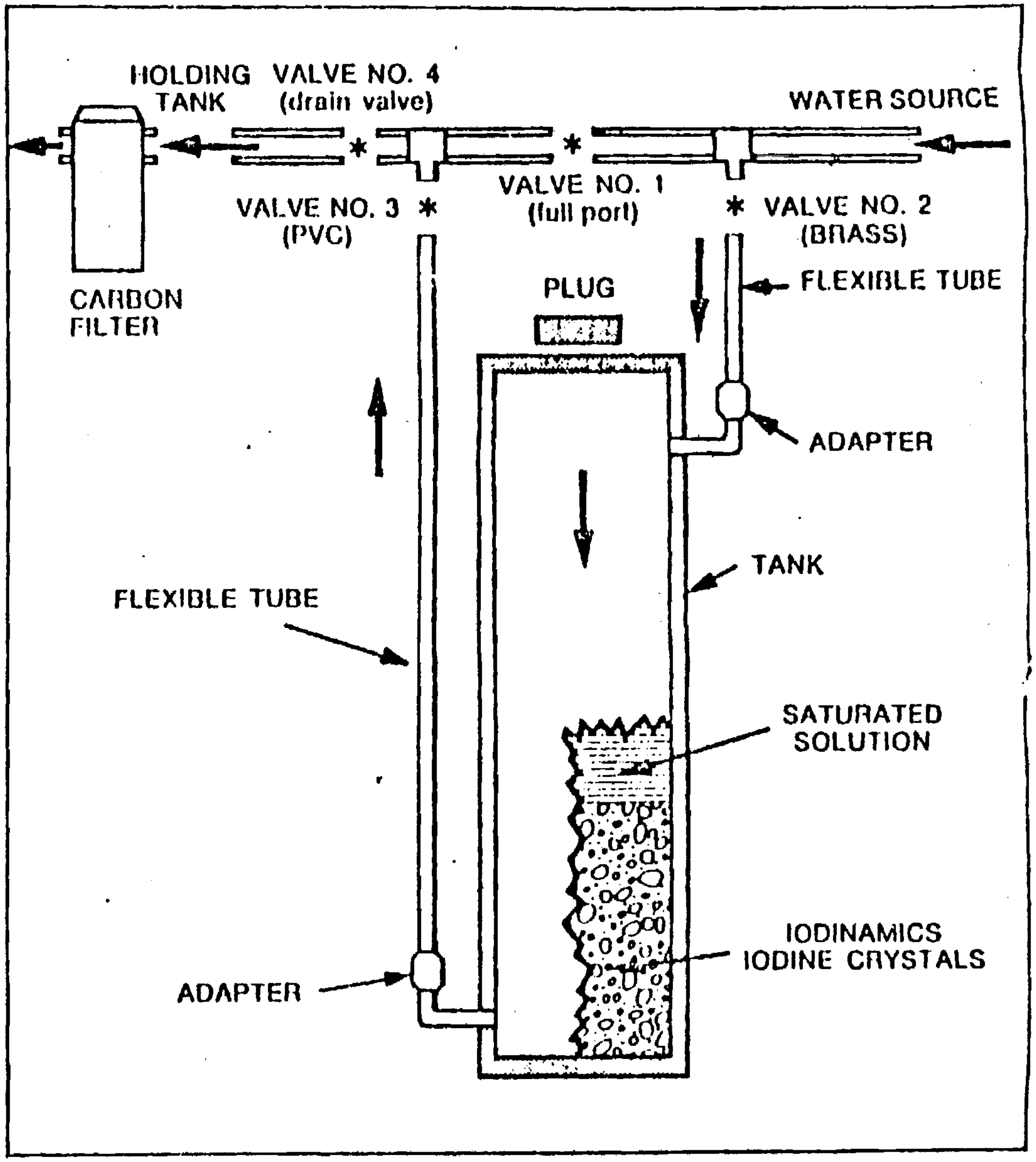
8. If sand is present, invert tees and use street ells to return to Iodinator®.

9. Check iodine crystal level in Iodinator® tank at least once a year. To do this completely close valves No. 2 and 3. Open plug slightly to relieve pressure, then remove plug from tank and measure depth of iodine crystal bed with a ruler or clean rod. Should iodine bed be 2/3 depleted, replenish with a new supply of Iodinamics Iodine Crystals.

NOTE: The carbon filter must be installed in line after the holding tank. The carbon filter media or element is to be changed before it is completely spent and no longer effective.

® IODINATOR is a registered trade mark of Iodinamics Corporation

IODINAMICS IODINATOR®



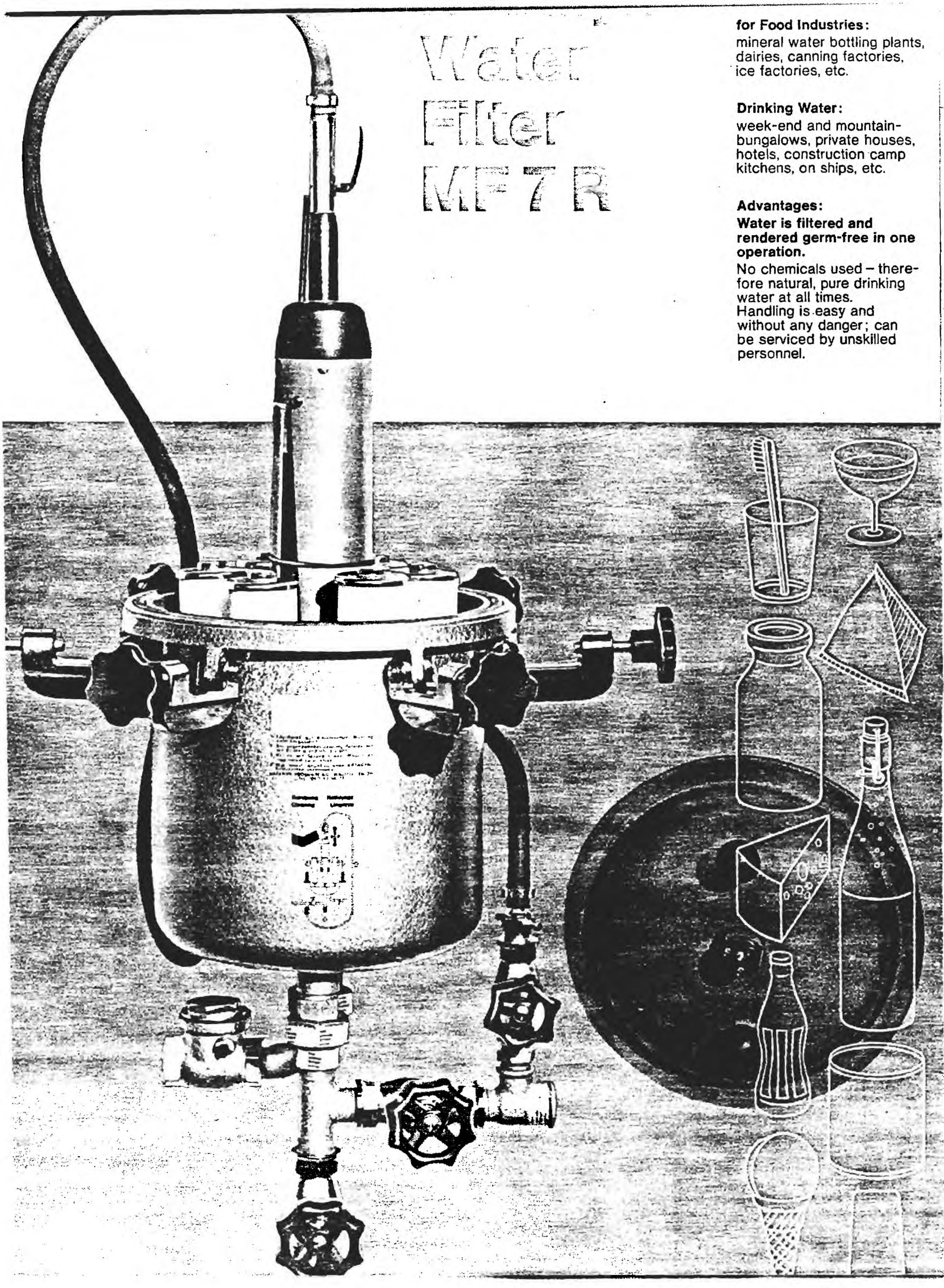
IODINAMICS

CORPORATION

A subsidiary of Continental Water Conditioning Corporation

P.O. BOX 20018 ☐ EL PASO, TEXAS 79998

Water Filter MF 7 R



for Food Industries:
mineral water bottling plants, dairies, canning factories, ice factories, etc.

Drinking Water:
week-end and mountain-bungalows, private houses, hotels, construction camp kitchens, on ships, etc.

Advantages:
Water is filtered and rendered germ-free in one operation.
No chemicals used – therefore natural, pure drinking water at all times.
Handling is easy and without any danger; can be serviced by unskilled personnel.

Material

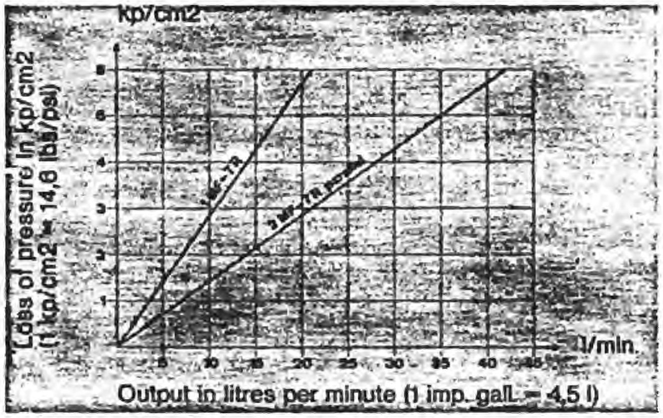
Filter of stainless steel, fittings of chromium plated brass
Maximum operating pressure admitted 88 lbs/psi (6 atü)

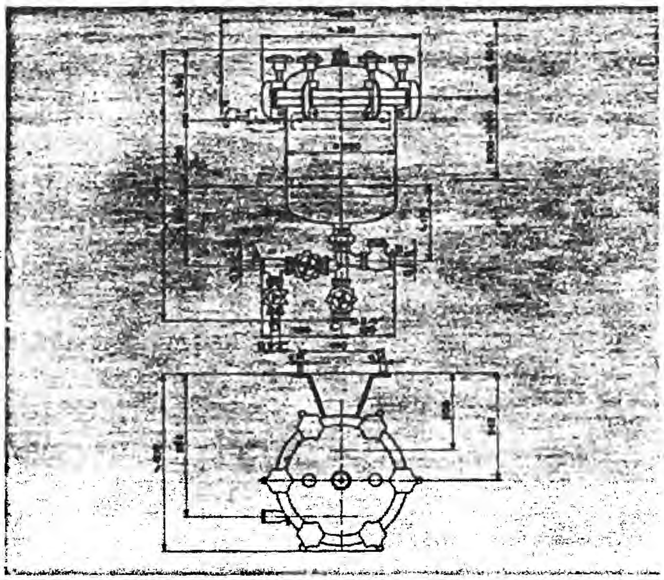
Pressure tested	146 lbs/psi (10 atü)
Connections (female threads)	3/4" G
Fixing on the wall with 4 stone bolts	
Net weight with 7 Filter Candles Nr. 4 and cleaning device	63 lbs (28,7 kg)
Gross weight packed	80 lbs (36,2 kg)
Volume	4 1/4 cu.ft. (0,12 m3)

Equipped with outlet tube if specially ordered. If the filter is to be installed in a room where it may suffer frost damage, it has to be ordered with a special drain cock on the clean water side.
Output according to flow-diagram, candles new or freshly cleaned; the flow-rate can differ from the ciphers given, according to the type and quantity of suspended matter contained in the raw-water.

Equipment

7 Katadyn Filter Candles Nr. 4 or Nr. 5
Automatic air-escape valve
Inlet tap and drain tap
Reaction trap in the pure water outlet
Candle Cleaning Device (with sliding rubber ring to adjust the pressure applied) and shut-off tap.





Mounting Instructions

Anchor the filter on the wall with the 4 stone bolts.

Connections: A – Raw water inlet
B – Pure water outlet
C – Drain
D – Connection to cleaning device

If the raw water inlet should be connected from the right side – i. e. inverting the normal situation – the inlet and drain taps are to be mounted so that the arrows on the taps correspond to the desired direction of the water-flow.
Screw in the Katadyn Filter Candles with the original rubber gaskets until they are firmly compressed by the candles.

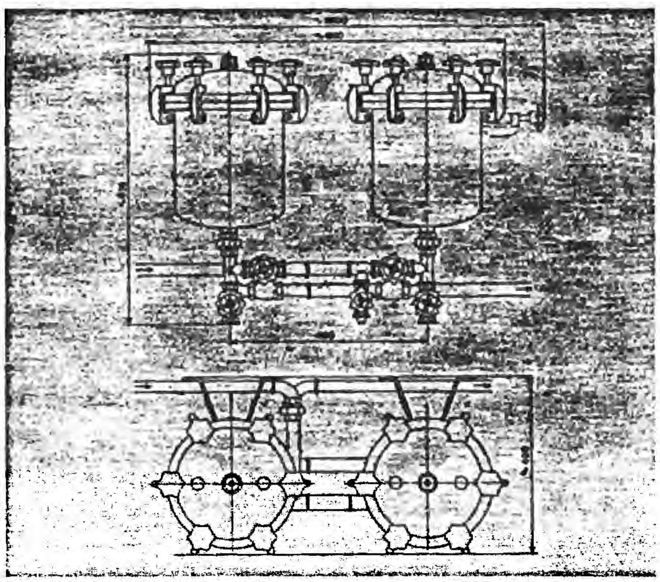
Operating Instructions

Close the filter. Turn off taps C and D. Turn on tap A. The air escapes through the air escape valve on the cover. Press down the central pin until some water emerges. The valve closes then automatically. When putting the filter in service for the first time, we recommend to disinfect the mains with our disinfecting-product «Micropur».

Cleaning

Close tap A, open C and D. Wait until the filter is empty then lift the lid. Put the cleaning device on the candles.
Press down the tap on the handle in order that water for rinsing runs at the same time. Brush a few times down and up, covering the whole surface of the candle. The pressure applied by the brushes can be adjusted by moving the rubber ring.
The life span of the filter candle depends on the degree of contamination of the water to be filtered, as with every cleaning operation, a thin layer of the ceramic material is brushed off.
We recommend to replace the filter candle when the ceramic material has worn down to a diametre of 1 5/8" (5" circumference) at its thinnest point. Make sure that the candle is free from hairline cracks. Such damages become immediately noticeable by an increased water flow as compared to the usual flow rate.

Measurements indicated in millimetres.
Construction subject to alterations.



Printed in Switzerland

Developed and manufactured by

Katadyn Products Ltd.
CH - 8304 Wallisellen

Distributors:

APPENDIX B

CULLIGAN DISINFECTION EQUIPMENT

Macondray & Co., Inc.
(A Member of the Boustead Group of Companies)

Filipinas Life Building, Ayala Avenue
Makati, Metro Manila, Philippines
Airmail: P.O. Box 7076 Airport
Local: P.O. Box 768 Manila
Tel: 88-98-41
Telex: 63553 MCNDRY PN
Cable: MACONDRAY

WT-LL-062/80

18 February 1980

Dr. Henry Van - Consultant
Embassy of the U. S. A.

Subject : Culligan Chemical Feeders

Dear Sir :

We are pleased to submit our dealers price for the above mentioned subject.

MODEL NO.	CAT. NO.	(INDENT PRICE) FOB FACTORY	FORWARD SALE
CT-4A	9015-62	$ 320.00	₱5,800.00
CT-10A	9015-63	$ 350.00	₱6,000.00
CT-20A	9015-64	$ 360.00	₱6,200.00
DT-60A	9015-69	$ 430.00	₱7,500.00
DT-120A	9015-70	$ 450.00	₱7,800.00

Attached is the technical brochure that will aid you for your requirements. We thank you for your interest and we are looking forward for your earliest favorable reply.

Very truly yours,

MACONDRAY & CO., INC.

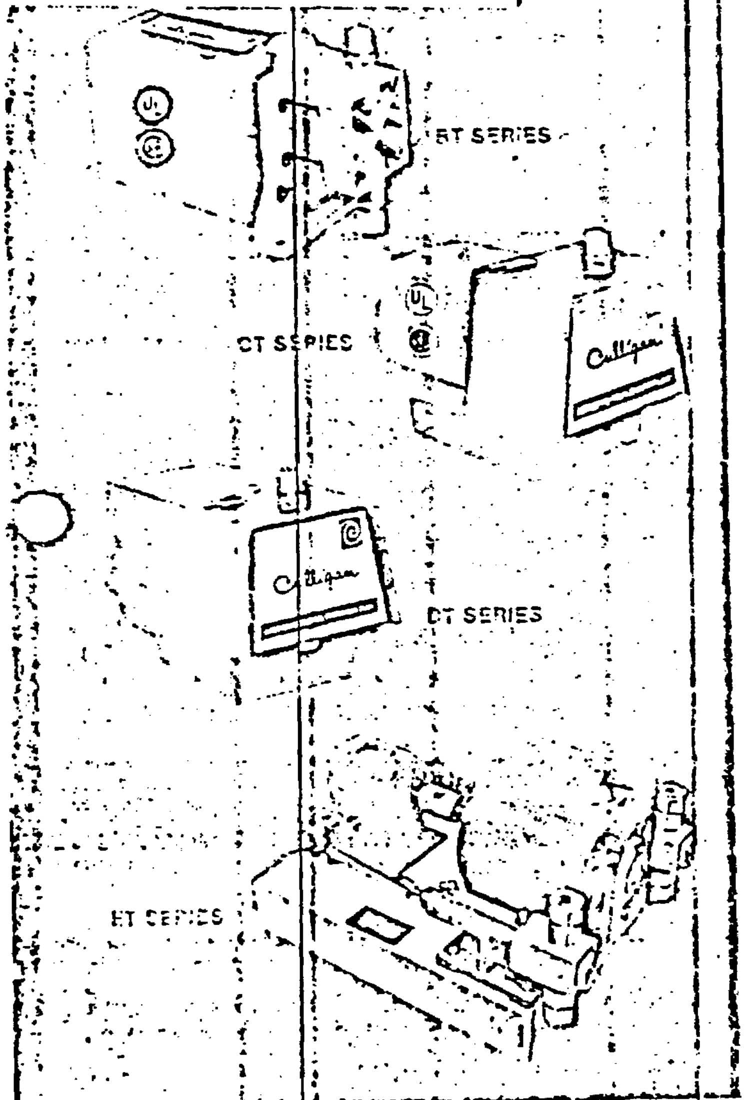
EDWIN C. DAMIAN
Sales Manager
Water Treatment Sales
Engineering

MRA/mnf

att. a/s

Michelangelo R. Aguilar
Sales Engineer
Water & Waste Treatment Dept.

Macondray & Co., Inc.
(A Member of the Boustead Group of Companies)
4th Floor, Filipinas Life Building
Ayala Avenue, Makati, Metro Manila
P. O. Box 765, Manila
Tels.: 88-95-41, 88-92-07, 88-48-32
Telex: 8630 MACTEX PN, 3502 MACTEX PN



CHEMICAL FEEDERS AND FEEDER SYTEMS

Philippine Representative
MACONDRAY & CO., INC.
Engineering Division
4th Flr., Filipinas Life Bldg.
Ayala Avenue, Makati
Tels. 88-98-41; 88-92-07

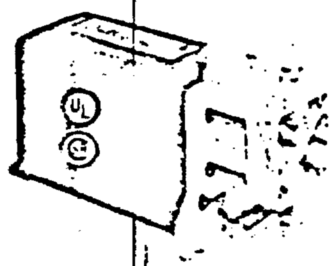
- purification of drinking water
- iron (red) water control
- sulfur water control
- boiler water treatment
- cooling water treatment
- coagulation feed
- corrosion control
- acid water control

Culligan WE TREAT WATER SERIOUSLY.TM

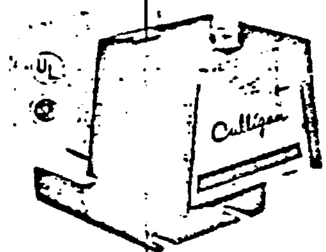
Culligan

CHEMICAL FEEDERS

Diaphragm Type Feeders

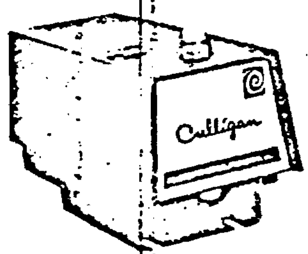


BT SERIES
Air cooled chemical feeders ideally suited for intermittent pumping requirements at normal water pressure, such as encountered in private wells and residential applications. The two feed capacity choices of 5 and 20 gpd are perfect for chlorination and acid water correction. Extremely reliable, these feeders pump against pressure up to 75 psig.



CT SERIES
Designed to work in rough environments, CT Feeders perform whether installed inside or outside. Oil-cooled motors are totally sealed against dusty, arid or humid conditions. Available in 4, 10, or 20 gpd capacities. These feeders are very rugged, built for continuous duty and are capable of pumping against pressures up to 100 psig.

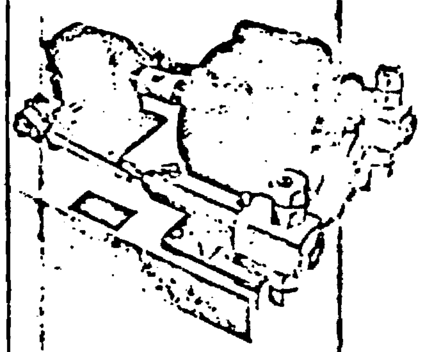
Electrical components of BT & CT feeders listed with U.L. and C.S.A.



DT SERIES
These feeders have the pumping capacity to handle jobs requiring larger feed rates than BT or CT Series. DT Feeders come in two models, 60 and 120 gpd. Like the CT Feeders, all models can pump against pressures as high as 100 psig. Units employ a fan cooled motor and are built to perform accurately and continuously.

Piston Type Feeders

ET SERIES
Fractional horsepower motors with drip-proof construction power these piston-type pumps. Heavy industrial-duty construction allows these feeders to work against pressures as high as 2,000 psig. Standard ET feeders are available in 36, 156, 480, and 1,440 gpd capacities. Feeders feature ± 1% repetitive accuracy. Single and double headed (individually adjustable) models are available.

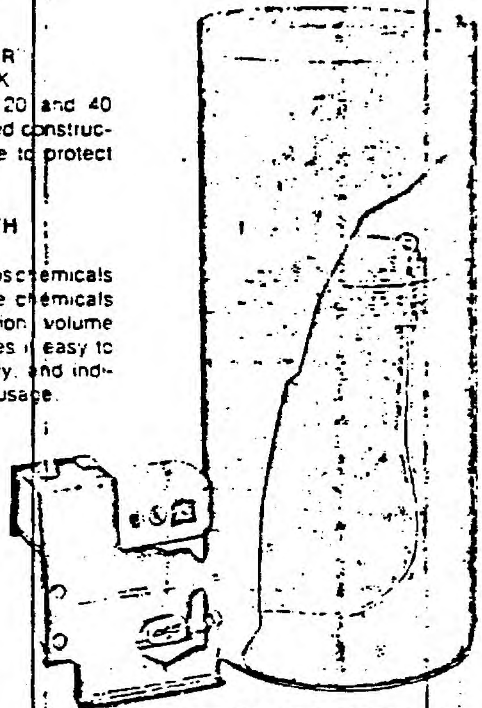


Philippine Representative
MACONDRAY & CO., INC.
Engineering Division
4th Flr., Filipinas Life Bldg.
Ayala Avenue, Makati
Tels. 88-93-41; 88-92-07

AND FEEDER SYTEMS

Philippine Representative
MACDONALD & CO., INC.
Engineering Division
4th Flr., Filipinas Life Bldg.
Ayala Avenue, Makati
Tels. 88-95-41; 88-92-07

Feeder Systems



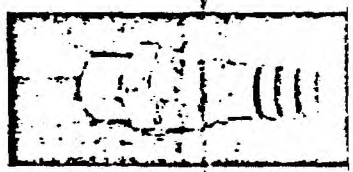
HIGH DENSITY LINEAR POLYETHYLENE TANK
Tanks are available in 20 and 40 gallon sizes. Thick walled construction makes them durable to protect your installation.

OPAQUE DESIGN WITH VOLUME MARKER
Opaque tank design keeps chemicals "fresh". Light sensitive chemicals remain potent. Solution volume marker inside tank makes it easy to dilute chemicals properly, and indicates rate of chemical usage.

FULL ENTRY TOP
Tank top is completely removable for quick, easy chemical filling. No more chemical spill problems encountered during filling.

FLOODED SUCTION
Flooded suction keeps the feeder constantly primed. Eliminates all feeder priming problems as well as time spent priming the feeder after servicing or cleaning.

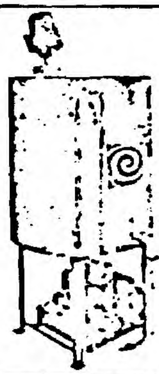
FLOATING INLET
Uniquely-designed floating inlet stops plugging problems. The floating inlet stays clear of chemical sludge in the bottom of the tank at all times.



SHUT-OFF VALVE FOR SERVICING
Handy shut-off valve allows the tank and feeder to be serviced without emptying tank. Eliminates worries of damage from chemical spills.

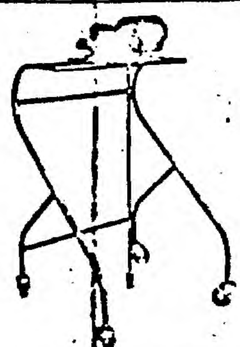
BRACKET FOR FLOOR OR WALL MOUNT
Chemical-resistant bracket mounts all Culligan diaphragm feeders either on the floor near the tank or wall. Rubber feet keep the bracket from marring walls or floors while minimizing vibrational noise.

SCALE FIGHTER INJECTION FITTING
Fitting can be installed in any position. Special O-ring design flexes constantly to clean the fitting of scale and other deposits, to keep service calls to a minimum.



ET SYSTEMS
Each ET System includes 50, 100, or 150 gallon steel tank with hinged tank lid, stand for mounting pump, brass suction valve, gauge glass for easy liquid level determination. ET Feeder systems come completely assembled and ready to install.

When feeding chemicals directly from a 55 gallon drum is required, the portable pump stand (shown at right) allows the pump to be rolled from one drum to the next.



Culligan CHEMICAL FEEDERS AND FEEDER SYTEMS

OPTIONAL FEATURES

DIAPHRAGM FEEDERS

Anti-Siphon Valve: Special purpose valve prevents over-feeding due to siphon action of water supply. Use for applications where the discharge is lower than the chemical feed tank or the discharge line is subject to suction. One size valve fits all diaphragm feeders.

Acid Feeders: Upon request, factory will provide a special feeder equipped with special plastic and rubber parts necessary to feed acids over 10% strength. These special parts are factory installed so that no field changeover is required.

Acid Feed Kit: Kit contains all parts necessary for field changeover of standard feeder for acid service.

Motor Electrical Option: Factory can provide any model feeder with 220 volt 50/60 Hertz motor for installation without transformer when required.

Transformer: Special transformer can be used to hook up 120 volt feeder to 220 volt electrical supply when permitted by local electrical codes.

PISTON FEEDERS

A wide range of options is available for these feeders and feeder systems. Consult the factory for specific application data.

PERFORMANCE DATA — DIAPHRAGM FEEDERS

Model Number		Capacity*	
Feeder Only	Assembly With Tank	Feeder	Tank
BT-5	BT-5A	5 gpd 19 lpd	20 gal 76 liters
BT-20	BT-20A	20 gpd 76 lpd	20 gal 76 liters
CT-4	CT-4A	4 gpd 15 lpd	20 gal 76 liters
CT-10	CT-10A	10 gpd 38 lpd	20 gal 76 liters
CT-20	CT-20A	20 gpd 76 lpd	20 gal 76 liters
DT-60	DT-60A	60 gpd 227 lpd	40 gal 151 liters
DT-120	DT-120A	120 gpd 454 lpd	40 gal 151 liters

PERFORMANCE DATA — PISTON FEEDERS

Model Number		Capacity*	
Feeder Only	Assembly With Tank	Feeder	Tank
ET-36	ET-36A	36 gpd 136 lpd	55 gal 208 liters
ET-156	ET-156A	156 gpd 590 lpd	100 gal 378 liters
ET-480	ET-480A	480 gpd 1 817 lpd	100 gal 378 liters
ET-1440	ET-1440A	1 440 gpd 5 450 lpd	150 gal 568 liters

*Capacity expressed in U.S. gallons/day or liters/day

OPERATING DATA

DIAPHRAGM TYPE FEEDERS (BT, CT and DT Series)

Temperature Range: 45°F — 120°F • 7°C — 50°C

Chemical Limits:(1) 10% Hydrochloric Acid (HCl) • 10% Caustic Soda (NaOH) • 15% Chlorine (Bleach) • No organic solvents

Feeder	Pressure(2)	Electrical
BT	0-75 psig 0-5.2 bar	1/12 Hp 1.0 Amps
CT	0-100 psig 0-7 bar	1/12 Hp 1.0 Amps
DT	0-100 psig 0-7 bar	1/10 Hp 1.3 Amps

All feeders 120V, 60 Hz, 1 Phase

PISTON TYPE FEEDERS (ET Series)

Temperature Range: 32°F — 180°F • 0°C — 80°C

Chemical Limits:(1) 0-50% Caustic Soda (NaOH) • 85-98% Sulfuric Acid (H_2SO_4) • No chlorine (Bleach) • No HCl & HNO_3 • No Phosphates

Feeder	Pressure(2)	Electrical
ET-36	0-1,000 psig 0-70 bar	1/4 Hp 5.0 Amps
ET-156	0-500 psig 0-35 bar	1/3 Hp 5.2 Amps
ET-480	0-225 psig 0-15.5 bar	1/3 Hp 5.2 Amps
ET-1440	0-200 psig 0-14 bar	3/4 Hp 10.5 Amps

All feeders 120V, 60 Hz, 1 Phase

(1) Special materials of construction optional to handle chemicals beyond standard unit limits

(2) Pressure expressed in metric "bar" is preferred (SI-Society International) unit. 1.0 bar = 1.02 kg/cm²

8176 17

1-8 Printed in U.S.A.

~~Philippine Representative~~
~~MC CLOUHAY & CO., INC.~~
Engineer[illegible] Division
4th Flr., Filipinas Life Bldg.
Ayala Avenue, Makati
Tels. 88-[illegible]-41; 88-92-07

APPENDIX C

OTHER AVAILABLE DISINFECTION DEVICES

postal address: p.o. box 140, leidschendam, the netherlands
office address: nw havenstraat 6, voorburg (the hague)
telephone: 070 - 69 42 51, telegr.: worldwater the hague, telex: 33604

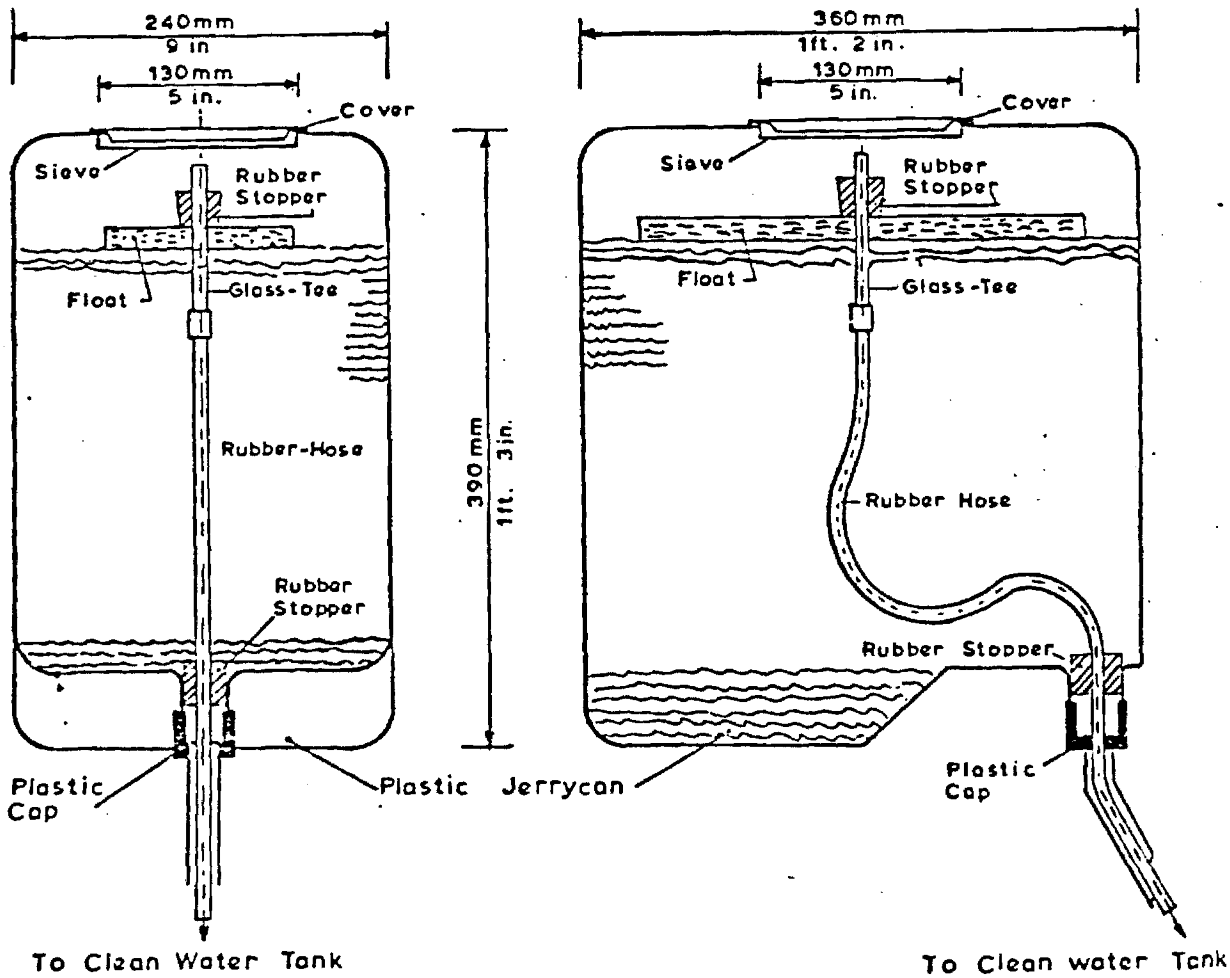
Title: Chlorinator

Country:

Characteristics:

Principle/Description:

A constant level is maintained above the glass T. The solution should freely flow (not sucked) through the orifice to maintain the constant head.

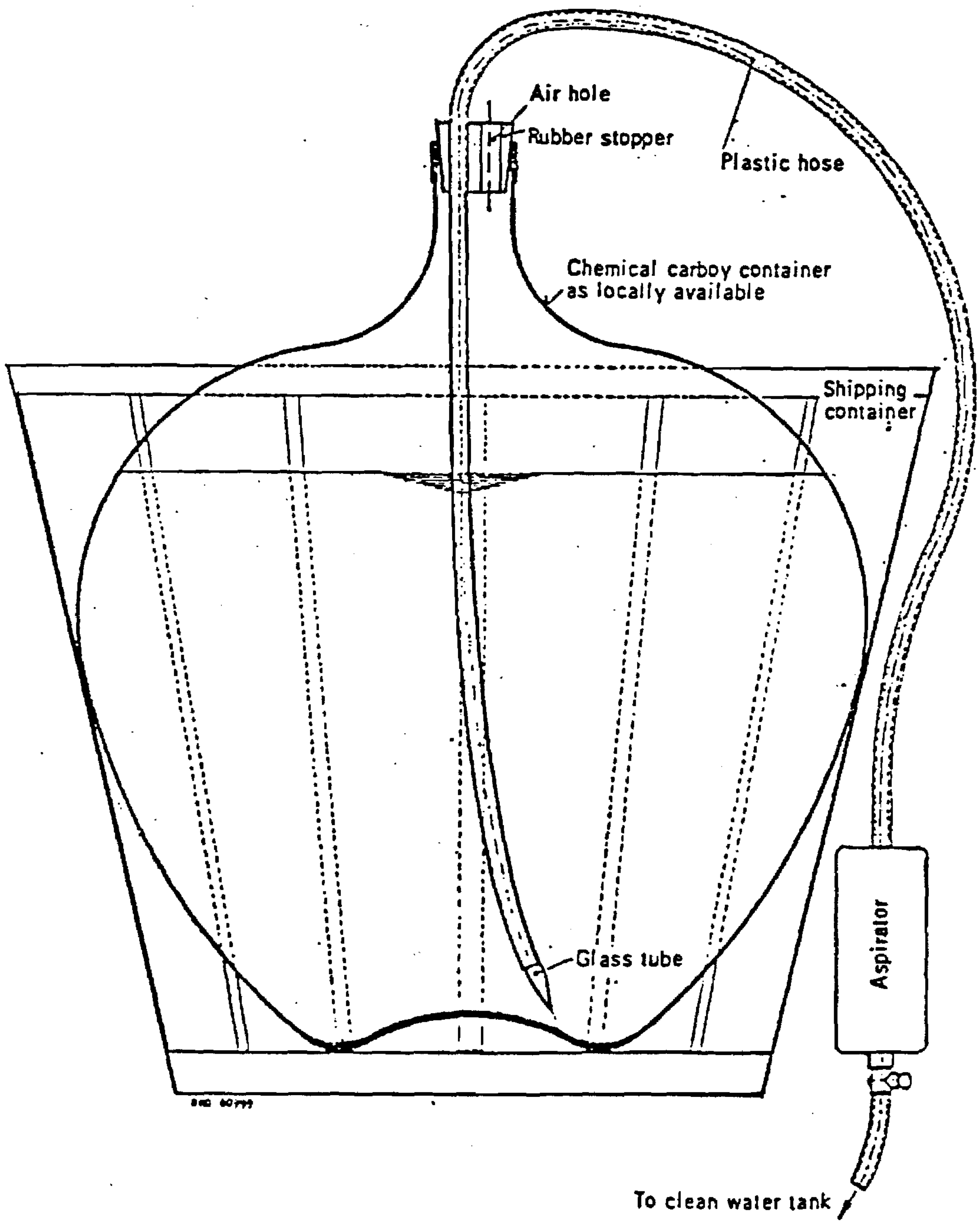


PLASTIC JERRYCAN CHLORINATOR

Reference: Fisher, B.W.M., P.O. Box M142, Accra, Ghana

Remarks:

FIG. 22. CARBOY HYPOCHLORINATOR

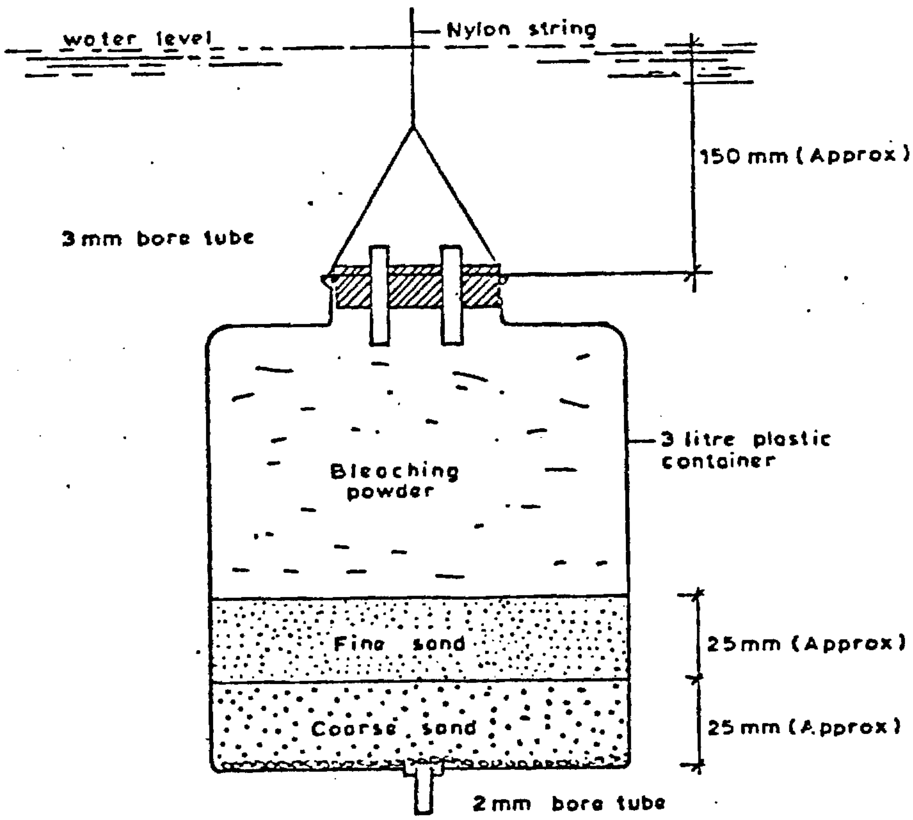


Reference: George W. Reid, "A Catalog of Water Supply and Waste Disposal Methods for Individual Units," Bureau of Water & Environmental Resources Research, Univ. of Oklahoma, Norman, Okla., October 1975.

Title:	Hypochlorinator
Country:	Tanzania
Characteristics:	Use of Plastic Container

Principle/Description:

Chlorination of open wells.



Reference:	Shrivastava, L. P. "Report on Non-piped water supply sources in Dar-es-Salaam, Referred in "Master of Engg. Thesis, University of Jabulpur, India
Remarks:	total cost (1975) T.Shs. 43 (U.S.$6.00)

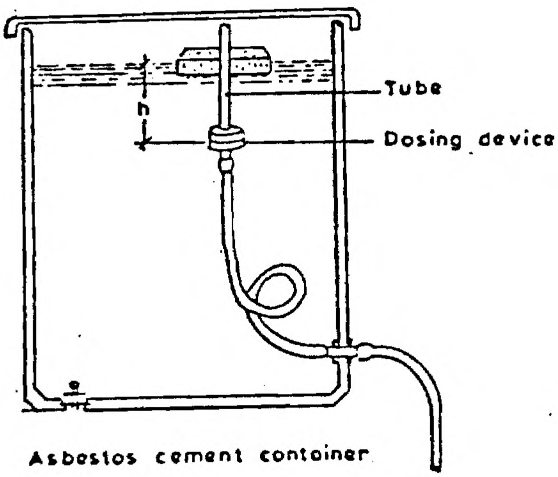
Title: Hypo-chlorinator

Country: Venezuela/Peru

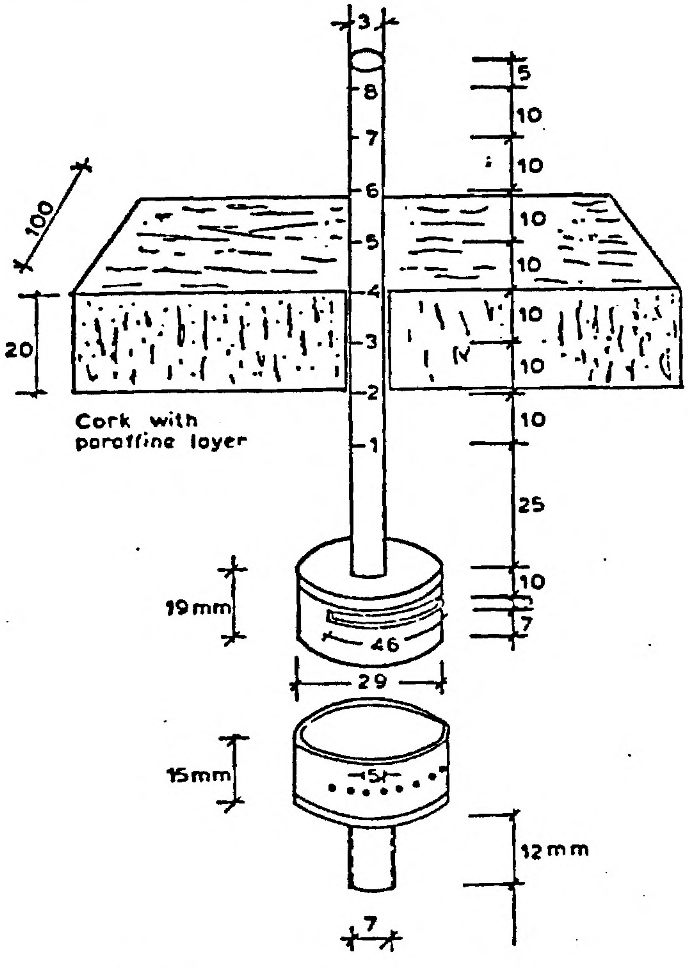
Characteristics:

Principle/Description:

Discharge is determined by the number of open orifices uncovered by the slit. The head can also be varied by adjusting the float.



Asbestos cement container



DETAIL ; Material: silver

Reference: Ing. Luis C. Bowilla, G. Venezuela, reported by Dante Munoz, M.T. de Alvear 634 - 40P Buenos Aires

Remarks:

postal address: p.o. box 140, leidschendam, the netherlands
telephone: 070 - 13 42 51, telegr.: worldwater the hague, telex

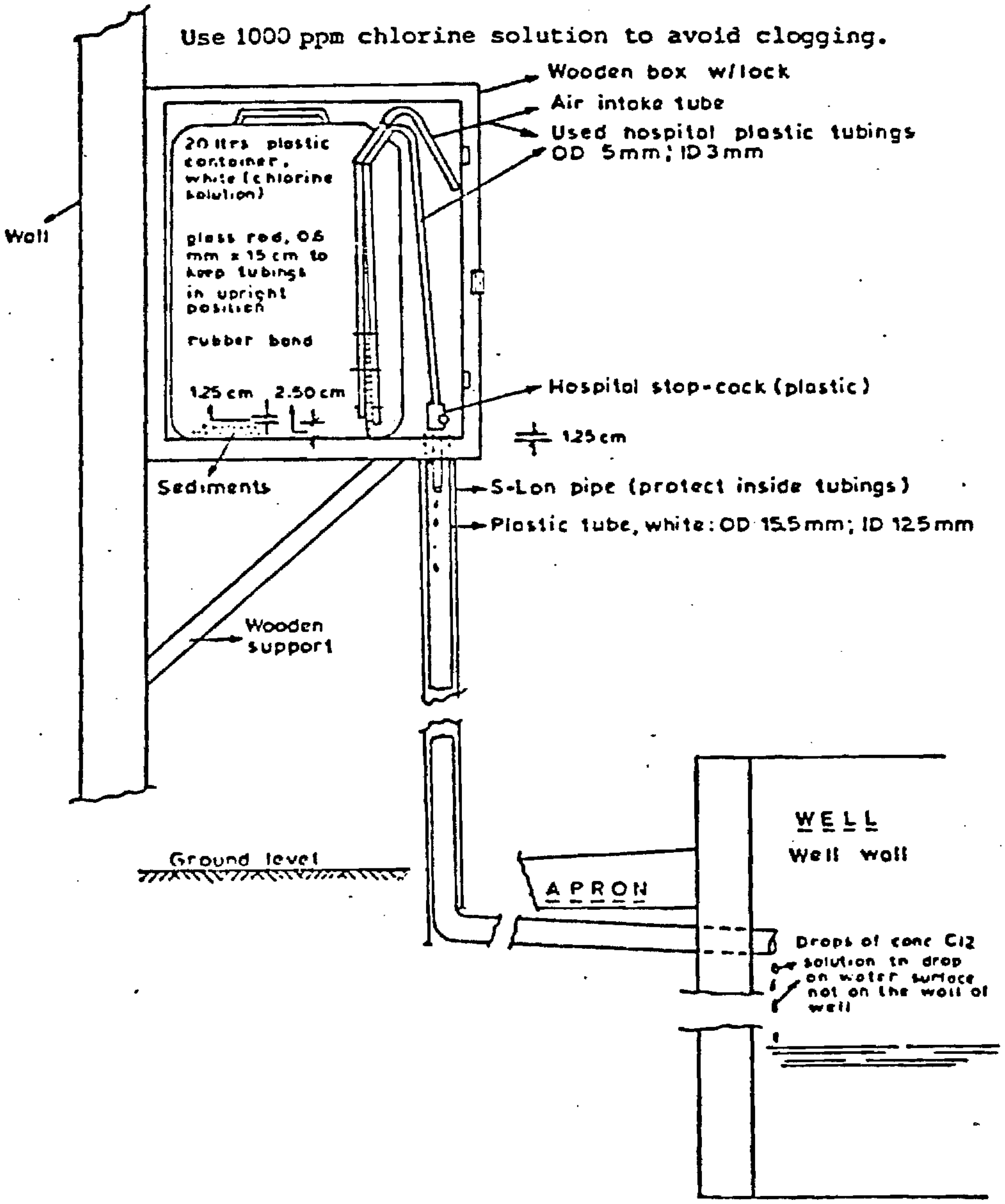
Title: Simple Method Chlorinator

Country: Maldives

Characteristics:

Principle/Description:

Use 1000 ppm chlorine solution to avoid clogging.



Reference: Hassan Maniku, MWSA, Malè, Maldives

Remarks: total costs (1975) approximately $61.40

postal address: p.o. box 140, leidschendam, the netherlands
office address: nw havenstraat 6, voorburg (the hague)
telephone: 070 - 69 42 51, telegr.: worldwater the hague, telex: 33604

Title:	Hypochlorinator
Country:	Brazil
Characteristics:	Emergency construction

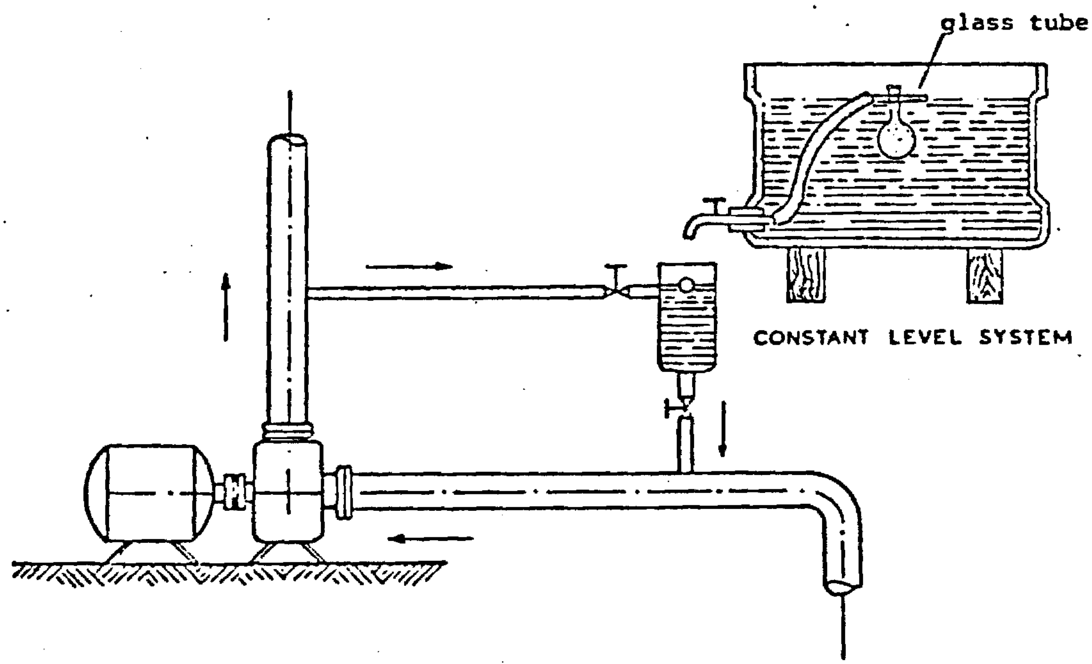
Principle/Description:

material: asbestos cement reservoir - rubber hose, glass tube

constant dosing of a hypochlorite solution by arranging a constant head of liquid above the open rubber hose, a flask (weighted with gravel) serves as a float.

The dose can be changed by:

1. changing the opening of the Hoffmann tweezer
2. changing the concentration of the solution



Reference:	Rossin, A.C., CETESB, Av.Prof. Frederico Hermann, Jr. 345 Alto de Pinheiros 05459-Sao Paulo S.P., Brazil
Remarks:	total cost (1975) US$12.-

postal address: p.o. box 140, leidschendam, the netherlands
office address: nw havenstraat 6, voorburg (the hague)
telephone 070 - 69 42 51, telegr.: worldwater the hague, telex: 33601

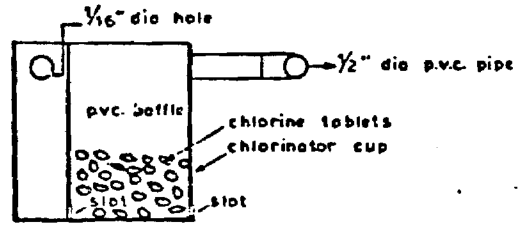
Title: Drip feed chlorinator

Country: Jamaica

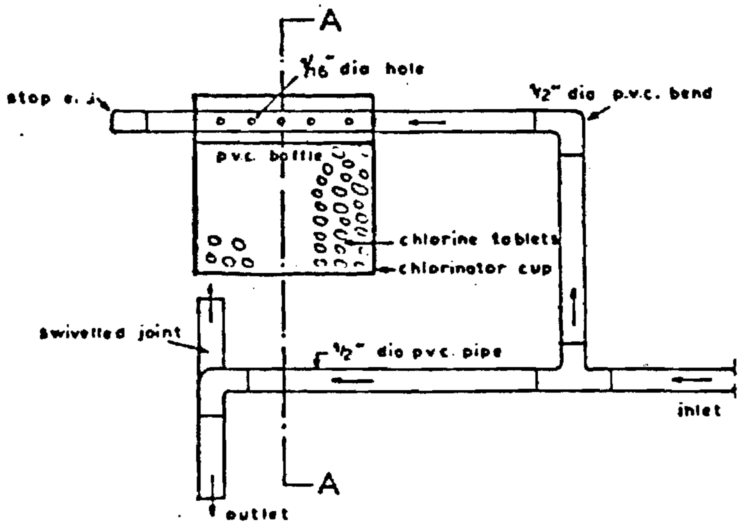
Characteristics: Plastic

Principle/Description:

Chlorine tablets are dissolved at the bottom of a cup and replace accordingly. A swing arm can be used to control the amount of water led into the chlorinator.



SECTION A A



Reference: Reid, R., P.O. Box 384, Kingston 5, Jamaica

Remarks:

who international reference centre for community water supply

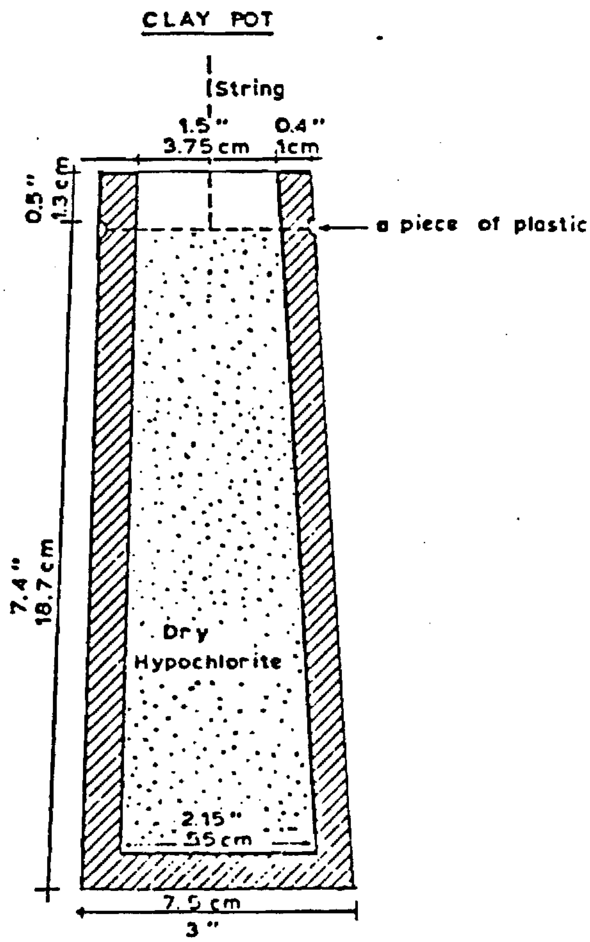
postal address: p.o. box 140, leidschendam, the netherlands
office address: nw havenstraat 6, voorburg (the hague)
telephone: 070 - [illegible], telegr.: worldwater the hague, telex: [illegible]

Title: Clay pot hypochlorinator

Country: Kenya

Characteristics: Local construction

Principle/Description: Material: one part of clay to two parts of ash from rice husks. The pot should be baked in an oven. The pot is filled with dry hypochlorite and hung in the water. The concentration of chlorine in the water can be decreased by rubbing the pot with wax candle and closing off part of the porous wall.



Reference: Chatiketu, S., WHO Sanitarian, NIE SHS-05, P.O. Box 765, Kano, Nigeria

Remarks:

who international reference centre for community water supply

postal address: p.o. box 140, leidschendam, the netherlands
office address: nw havenstraat 6, voorburg (the hague)
telephone [illegible] 42 51, telegr.: worldwater the hague, telex: 33604

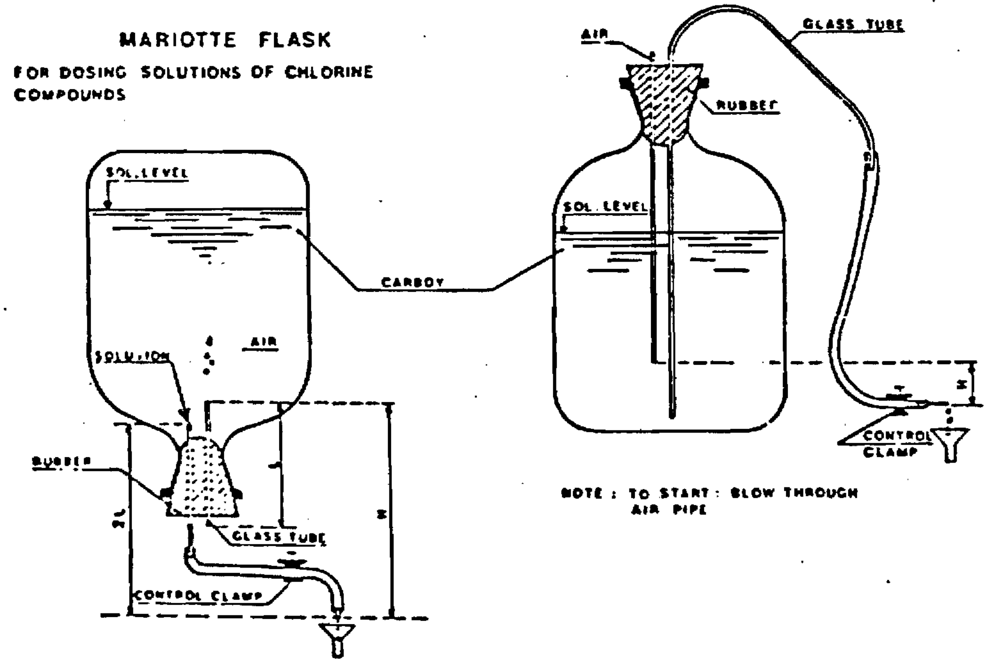
Title: Solution feeder

Country: Brazil

Characteristics: from laboratory glass ware

Principle/Description:

Solution feeding device with a constant head. Air is automatically sucked in by the lowering level of the liquid keeping the head constant at H.



Reference: Prof. J.M. de Azevedo Netto, University of Sao Paulo, Brazil

Remarks:

postal address, p.o. box 1[illegible], leidschendam, the netherlands
office address, [illegible] (the hague)
telephone 070-[illegible] 42 51, telegr.: worldwater the hague, telex: 33004

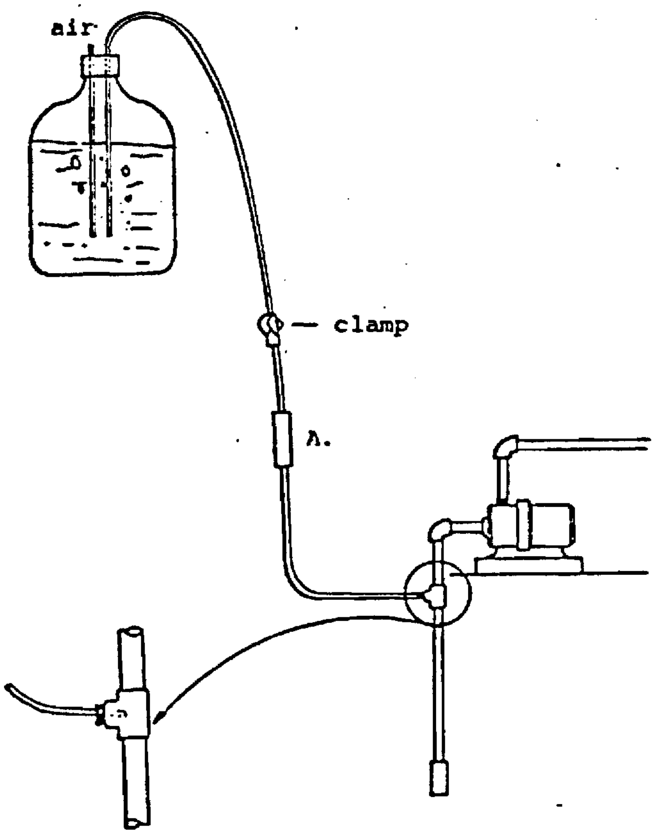
Title: Solution feeder

Country: Peru

Characteristics:

Principle/Description:

A solution feeder is connected to the suction line of a pump. A. is a buret indicating the dosage.



Reference: Lopez, D.C. Manual para la desinfección de aguas mediante la cloración. Ministry of Health, Peru

Remarks: reported by H. Weitzenfeld PAHO, El Salvador

APPENDIX D

EXAMPLE OF THE DECISION MODEL

APPENDIX D

EXAMPLE FOR USING THE DECISION MODEL

To provide a better understanding of the proposed evaluation model, the following hypothetical example is prepared for the conditions existing at Agsalanan, Philippines. Two disinfection devices are selected to demonstrate the mechanics of the evaluating process. Table 6 shows the cost and characteristics of the devices relevant to the needs of the model.

EFFECTIVENESS EVALUATIONS

The procedure to be used in this evaluation is called the Effectiveness Analysis Model and is shown in Figure 11. The reader may refer to the "Subsequent Monitoring and Evaluation Program" Chapter Seven, for further clarification of the concept of effectiveness or worth. Effectiveness, as stated earlier, refers to the extent of how well a device will satisfy a desired requirement.

In this example, the devices are the: (a) Hypochlorinator (WATER-SURE 050) and (b) Iodinator (Iodinamics eight-pound size) designated as A_1 and A_2, respectively. These are evaluated in terms of several measures of effectiveness or evaluating factors (M_1, M_2, ... M_{21}). Table 7 lists the twenty-one measures of effectiveness in order of relative importance. After

TABLE 6
COST AND CHARACTERISTICS FOR AN EXAMPLE

Device	Manufacturer	Model	Unit Cost*	Disinfectant Cost**	Minimum Pressure Required psi	Maximum Flow Capacity gpm	Electricity Required
Hypochlorinator	World Water Resources, Inc.	WATER-SURE 050	$132.25	$8.26/lb	1.3	20	No
Iodinator	Iodinamics Corporation	Eight-pound size	$336.60 + 8 lb. of I_2	$16.41 up to 100 lb $15.46 200 lb to 900 lb	2.5	10	No

*Price in the U.S.
**Price does not include import, sales, and shipping costs.

TABLE 7
EFFECTIVENESS CRITERIA AND RELATIVE WEIGHTS
FOR EVALUATING THE DISINFECTION DEVICES
AND DISINFECTANTS FOR AN EXAMPLE

	Effectiveness Measures	Relative Importance: With Respect to Next Item on the List* (w)	Relative Importance: With Respect to Last Item on the List	Normalized Relative Weights (NRW)
M_1	Satisfaction of Hydraulic Requirements**	2.0	656.10	0.354
M_2	Capital Cost of the Device	1.0	328.05	0.177
M_3	Cost of Disinfectant	1.5	328.05	0.177
M_4	Resupply to the Field	2.0	218.70	0.118
M_5	Disinfection Power	2.0	109.35	0.059
M_6	Operation Reliability	1.5	54.68	0.030
M_7	Maintainability	1.5	36.45	0.020
M_8	Dosing Accuracy	1.0	24.30	0.013
M_9	User Acceptability	1.0	24.30	0.013
M_{10}	Installation or Modification Difficulties and Associated Cost	2.0	24.30	0.013
M_{11}	Safety	1.5	12.15	0.007
M_{12}	Flow-Reduction Restrictions of Device	1.0	8.10	0.004
M_{13}	Pressure-Loss Restrictions of Device	1.5	8.10	0.004
M_{14}	Training Requirements for Operations	1.0	5.40	0.003
M_{15}	Training Requirements for Maintenance	2.0	5.40	0.003
M_{16}	Power Cost	1.0	2.70	0.001
M_{17}	Field Storage Difficulties of Disinfectant	1.2	2.70	0.001
M_{18}	Durability	1.5	2.25	0.001
M_{19}	Susceptibility to Vandalism	1.5	1.50	0.001
M_{20}	Shelf Life of Disinfectant	1.0	1.00	0.001
M_{21}	Space Requirement	1.0	1.00	0.001
			1,854.58	1.001

*These values were the judgment of one person. Under real conditions, these should be the average of at least three, independent evaluations.

**This assumes that the device meets minimum hydraulic specifications, and power is available if needed.

preparing the list of measures of effectiveness, the procedure is the following:

1. Assign relative weights (w) to each of the "n" measures of effectiveness. These weights merely reflect the relative importance in a preset, arbitrary scale (Table 7). In this case, the scale selected is 1 to 2. In Column 2, "With Respect to Next Item on List", one can say, for instance, that maintainability is 1.5 times more important than dosing accuracy. Here, one is showing the relative importance of each measure of effectiveness with respect to the measure immediately below it on the list. In other words, the importance of M_7 is compared to M_8 using a scale of 1 to 2. Where the weight factor is 1.0, the two measures are considered to be of equal importance. The one-to-one comparison is done with all the twenty-one measures beginning with the last two, M_{20} compared to M_{21}, M_{19} compared to M_{20}, M_{18} compared to M_{19} and so on until M_1 is compared to M_2. Next, the numbers in Column 3, "With Respect to Last Item on the List", are obtained by multiplying the second number from the bottom in Column 2 by 1.00. The result is placed

immediately above the last number in Column 3. For example,

Col. 1	Col. 2		Col. 3
M_1	2.0	x	656.10
.	.		328.05
.	.		.
.	.		.
M_{18}	1.5	x	2.25
M_{19}	1.5	x	1.50
M_{20}	1.0	x	1.00
M_{21}	1.0	x	1.00

To obtain the numbers under Column 4, each number under Column 3 is divided by the sum of Column 3. For example,

Col. 1	Col. 3		Col. 4
M_1	656.10	+ 1,854.58 =	0.354
M_2	328.05	+ 1,854.58 =	0.177
.	.	.	.
.	.	.	.
.	.	.	.
M_{18}	2.25	+ 1,854.58 =	0.001
M_{19}	1.50	+ 1,854.58 =	0.001
M_{20}	1.00	+ 1,854.58 =	0.001
M_{21}	1.00	+ 1,854.58 =	0.001

Column 3 shows each item relative to the last one on the list. This, in turn, makes them relative to each other. Thus, power cost is 2.70 times as important as space requirement, and disinfection power is 109.35 times as important as space requirements. By normalizing Column 3 (i.e., the sum of the individual values is 1), one can derive the "Normalized Relative Weights" NWR (number under Column 4) for each of the measures of effectiveness. The validity of these values depends upon the decision maker's ability to provide accurate judgment in making the previous comparisons.

2. Assign a rating to each of the alternative devices or systems with respect to each of the effectiveness measures. The following criteria were used to assign the relative weights.

CRITERIA FOR THE EFFECTIVENESS ANALYSIS

Satisfaction of Hydraulic Requirements - This example assumes that the devices meet the minimum hydraulic requirements, although, in fact, the hypochlorinator does not.

Capital Cost of the Device - The hypochlorinator has a lower price and is, therefore, more attractive.

Cost of Disinfectant - Chlorine tablets required by the hypochlorinator are less expensive than iodine (see Table 6), although both materials are more expensive than other chemicals used for water disinfection.

Resupply to the Field - Both chlorine tablets and iodine must be imported; therefore, to some degree this requirement is not fully satisfied. In the Philippines, this is a severe handicap, and in other lesser developed countries (LDCs) this could be a problem unless the logistics of resupply are well established.

Disinfection Power - Generally, higher concentrations of iodine than chlorine are necessary to produce comparable bacterial kills under similar conditions.

Operation Reliability - Under this measure, the devices are weighted based on the assumption that the more sophisticated the system, the more it could be subject to operational problems. In this case, both systems are considered equally reliable.

Maintainability - Both systems are believed to require the same degree of maintenance.

Dosing Accuracy - Both devices are capable of adjustment to provide concentration in increments of two-tenths of a ppm.

User Acceptability - Iodine seems, at the same concentrations as chlorine, to produce a slightly more detectable taste than chlorine. This affects palatability of the water and may adversely affect its acceptance by the users. For this reason, iodine is considered less acceptable than chlorine.

Installation or Modification Difficulties and Associated Cost - From existing conditions at Agsalanan, the hypochlorinator requires more extensive modification of existing arrangements and a much higher cost of installation.

Safety - Both devices are believed to be equally safe.

Flow-Reduction Restrictions of Devices - The two devices require about the same degree of head loss for their operation. In both systems, the concentration of their respective disinfectant is regulated by the flow through the disinfectant material.

Training Requirements for Operation - There are no particular difficulties with the operation of either piece of equipment, but in both cases testing of the halogen residual would be needed. Training of an individual in the use of a test kit could be readily accomplished. The devices are rated equal in this respect.

Training Requirements for Maintenance - Little maintenance is required for either system other than replacing the disinfectant and testing the residual. The testing of the residual requires the same skills. Therefore, both devices require equal maintenance training.

Power Cost - Since there is no power requirement for these devices, both satisfy the requirement. Most rural areas in LDCs do not have electricity, and for this reason, it is desirable that a device does not require electricity.

Field Storage Difficulties of Disinfectant - Depending on the location of the water system needing the device, this measure of effectiveness can become quite important. Both iodine and chlorine must be kept in a dry and cool place. Therefore, the difficulties involved with both are similar.

Durability - The iodinator is constructed of much heavier material than the hypochlorinator and appears to be much more durable.

Susceptibility to Vandalism - Both devices require some kind of protection such as a housing to protect them. However, the hypochlorinator is more susceptible to vandalism, since it is more easily damaged than the iodinator.

Shelf Life of Disinfectant - Hypochlorite tablets have a shelf life of about six months, while the shelf life of iodine is indefinitely long.

Space Requirement - It is convenient that the device occupy minimum space and still accomplish the objective. It also reduces the shipping costs. In this case, the iodinator is more compact and requires less space.

Once the numbers in Table 8 for Column 3, "With Respect to Next Device", have been obtained, the numbers for Column 4 "With Respect to Last Device" are obtained as follows:

Col. 1	Col. 2	Col. 3	Col. 4
M_1	A_1	0.75	0.75
	A_2	1.00	1.00
			= 1.75
M_2	A_1	1.00	0.90
	A_2	0.90	0.90
			= 1.80
.	.	.	.
.	.	.	.
.	.	.	.
M_{20}	A_1	0.25	0.25
	A_2	1.00	1.00
			= 1.25
M_{21}	A_1	0.50	0.50
	A_2	1.00	1.00
			= 1.50

The numbers in Column 4 are obtained by dividing each member of Column 3 by their sum. These are the respective ratings of the devices for the measures of effectiveness (Table 8). The reason for this is to place all of the ratings derived for the various measures of effectiveness on the same basis, i.e., in the range of zero to one. Although any other common range could similarly be used. Once the respective weights for the measures of effectiveness and the respective ratings for each device are obtained, the decision maker has all the data necessary to perform the calculations outlined in Figure 11. Table 9 shows the data and calculations outlined in Figure 11 of overall effectiveness. The result shows that A_1 (hypochlorinator) is less efficient given the conditions at Agsalanan.

TABLE 8

SUMMARY OF RATINGS FOR AN EXAMPLE, r_{ij}

Effectiveness Measures	Devices*	Relative Effectiveness: With Respect to Next Device	Relative Effectiveness: With Respect to Last Device	Ratings r_{ij}	
M_1 Satisfaction of Hydraulic Requirements	A_1	0.75	0.75	r_{11}	0.43
	A_2	1.00	1.00	r_{12}	0.57
			Σ = 1.75		Σ = 1.00
M_2 Capital Cost of the Device	A_1	1.00	0.90	r_{21}	0.50
	A_2	0.90	0.90	r_{22}	0.50
			Σ = 1.80		Σ = 1.00
M_3 Cost of Disinfectant	A_1	1.00	0.95	r_{31}	0.50
	A_2	0.95	0.95	r_{32}	0.50
			Σ = 1.90		Σ = 1.00
M_4 Resupply to the Field	A_1	0.10	0.01	r_{41}	0.09
	A_2	0.10	0.10	r_{42}	0.91
			Σ = 0.11		Σ = 1.00
M_5 Disinfection Power	A_1	1.00	0.50	r_{51}	0.50
	A_2	0.50	0.50	r_{52}	0.50
			Σ = 1.00		Σ = 1.00
M_6 Operation Reliability	A_1	1.00	1.00	r_{61}	0.50
	A_2	1.00	1.00	r_{62}	0.50
			Σ = 2.00		Σ = 1.00
M_7 Maintainability	A_1	1.00	1.00	r_{71}	0.50
	A_2	1.00	1.00	r_{72}	0.50
			Σ = 2.00		Σ = 1.00

TABLE 8 (Continued)
SUMMARY OF RATINGS FOR AN EXAMPLE, r_{ij}

Effectiveness Measures	Devices*	Relative Effectiveness: With Respect to Next Device	Relative Effectiveness: With Respect to Last Device	Ratings r_{ij}	
M_8 Dosing Accuracy	A_1	0.80	0.80	r_{81}	0.44
	A_2	1.00	1.00	r_{82}	0.56
			Σ = 1.80		Σ = 1.00
M_9 User Acceptability	A_1	1.00	0.80	r_{91}	0.50
	A_2	0.80	0.80	r_{92}	0.50
			Σ = 1.60		Σ = 1.00
M_{10} Installation or Modification Difficulties and Associated Cost	A_1	0.10	0.10	r_{101}	0.09
	A_2	1.00	1.00	r_{102}	0.91
			Σ = 1.10		Σ = 1.00
M_{11} Safety	A_1	1.00	1.00	r_{111}	0.50
	A_2	1.00	1.00	r_{112}	0.50
			Σ = 2.00		Σ = 1.00
M_{12} Flow-Reduction Restrictions of Device	A_1	1.00	1.00	r_{121}	0.50
	A_2	1.00	1.00	r_{122}	0.50
			Σ = 2.00		Σ = 1.00
M_{13} Pressure-Loss Restrictions of Device	A_1	1.00	1.00	r_{131}	0.50
	A_2	1.00	1.00	r_{132}	0.50
			Σ = 2.00		Σ = 1.00
M_{14} Training Requirements for Maintenance	A_1	1.00	1.00	r_{141}	0.50
	A_2	1.00	1.00	r_{142}	0.50
			Σ = 2.00		Σ = 1.00

TABLE 8 (Continued)
SUMMARY OF RATINGS FOR AN EXAMPLE, r_{ij}

Effectiveness Measures	Devices*	Relative Effectiveness: With Respect to Next Device	Relative Effectiveness: With Respect to Last Device	Ratings r_{ij}	
M_{15} Training Requirements for Maintenance	A_1	1.00	1.00	r_{151}	0.50
	A_2	1.00	1.00	r_{152}	0.50
			Σ = 2.00	Σ =	1.00
M_{16} Power Cost	A_1	1.00	1.00	r_{161}	0.50
	A_2	1.00	1.00	r_{162}	0.50
			Σ = 2.00	Σ =	1.00
M_{17} Field Storage Difficulties of Disinfectant	A_1	1.00	1.00	r_{171}	0.50
	A_2	1.00	1.00	r_{172}	0.50
			Σ = 2.00	Σ =	1.00
M_{18} Durability	A_1	0.60	0.60	r_{181}	0.38
	A_2	1.00	1.00	r_{182}	0.63
			Σ = 1.60	Σ =	1.00
M_{19} Susceptibility to Vandalism	A_1	0.80	0.80	r_{191}	0.44
	A_2	1.00	1.00	r_{192}	0.56
			Σ = 1.80	Σ =	1.00
M_{20} Shelf Life of Disinfectant	A_1	0.25	0.25	r_{201}	0.20
	A_2	1.00	1.00	r_{202}	0.80
			Σ = 1.25	Σ =	1.00
M_{21} Space Requirement	A_1	0.50	0.50	r_{211}	0.33
	A_2	1.00	1.00	r_{212}	0.67
			Σ = 1.50	Σ =	1.00

*A_1 = Hypochlorinator (WATER-SURE 050)
A_2 = Iodinator (Eight Pound)

TABLE 9
SUMMARY OF RATINGS FOR AN EXAMPLE

Measures of Effectiveness (M)*	Relative Weights (w)	Devices	
		A_1	A_2
M_1	0.354	0.43	0.57
M_2	0.177	0.50	0.50
M_3	0.177	0.50	0.50
M_4	0.118	0.09	0.91
M_5	0.059	0.50	0.50
M_6	0.030	0.50	0.50
M_7	0.020	0.50	0.50
M_8	0.013	0.44	0.56
M_9	0.013	0.50	0.50
M_{10}	0.013	0.09	0.91
M_{11}	0.007	0.50	0.50
M_{12}	0.004	0.50	0.50
M_{13}	0.004	0.50	0.50
M_{14}	0.003	0.50	0.50
M_{15}	0.003	0.50	0.50
M_{16}	0.001	0.50	0.50
M_{17}	0.001	0.50	0.50
M_{18}	0.001	0.38	0.63
M_{19}	0.001	0.44	0.56
M_{20}	0.001	0.20	0.80
M_{21}	0.001	0.33	0.67

TABLE 9 (Continued)
SUMMARY OF RATINGS FOR AN EXAMPLE

$$E[A_1] = \sum_{J=1}^{21} w_j r_{ij} = (0.354)(0.43) + (0.177)(0.50) + (0.177)(0.50) + (0.118)(0.09) + (0.059)(0.50) + (0.030)(0.50) + (0.020)(0.50) + (0.013)(0.44) + (0.013)(0.50) + (0.013)(0.09) + (0.007)(0.50) + (0.004)(0.50) + (0.004)(0.50) + (0.003)(0.50) + (0.003)(0.50) + (0.001)(0.50) + (0.001)(0.50) + (0.001)(0.38) + (0.001)(0.44) + (0.001)(0.20) + (0.001)(0.33) = 0.42$$

$$E[A_2] = \sum_{J=1}^{21} w_j r_{ij} = (0.354)(0.57) + (0.177)(0.50) + (0.177)(0.50) + (0.118)(0.91) + (0.059)(0.50) + (0.030)(0.50) + (0.020)(0.50) + (0.013)(0.56) + (0.013)(0.50) + (0.013)(0.91) + (0.007)(0.50) + (0.004)(0.50) + (0.004)(0.50) + (0.003)(0.50) + (0.003)(0.50) + (0.001)(0.50) + (0.001)(0.50) + (0.001)(0.63) + (0.001)(0.56) + (0.001)(0.80) + (0.001)(0.67) = 0.64$$

BIBLIOGRAPHY

1. American Public Health Association, American Water Works Association, and Water Pollution Control Federation. 1976. Standard Methods for the Examination of Water and Wastewater. Washington: APHA.

2. Eckenrode, R. T. 1965. Weighting Multiple Criteria. Journal of Management Science. 12:180-192

3. International Reference Centre for Community Water Supply. 1977. Contributions to a Mail Survey on Practical Solutions in Drinking Water Supply and Wastes Disposal for Developing Countries. The Hague.

4. Miller, J. R. 1967. Report on a Systematic Procedure for Assessing the Worth of Complex Alternatives. Bedford, Massachusetts: Defense Documentation Center. Report AD662001.

5. Reid, W. George. 1975. A Catalog of Water Supply and Waste Disposal Methods for Individaul Units. Norman: University of Oklahoma. Bureau of Water and Environmental Resources Research.